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ABSTRACT

Ten lessons comprise this curriculum intended to assist vocational teachers in establishing and conducting an alcohol fuels workshop on engine modification and plant design. A glossary is provided first. The 10 lessons cover these topics: the alcohol fuel plant, feedstock preparation lab, distillation lab, fuel plant processes, plant design lab, fuel plant earnings, by-product uses, engine modification (spark ignition), engine modification (diesel), and government regulations and permits. Each lesson contains an instructor's sheet with objectives, class activities, lab preparation, and references; student learning activities; and class handouts. Following a bibliography is a list of supplies and equipment needed to teach the course. (YLB)

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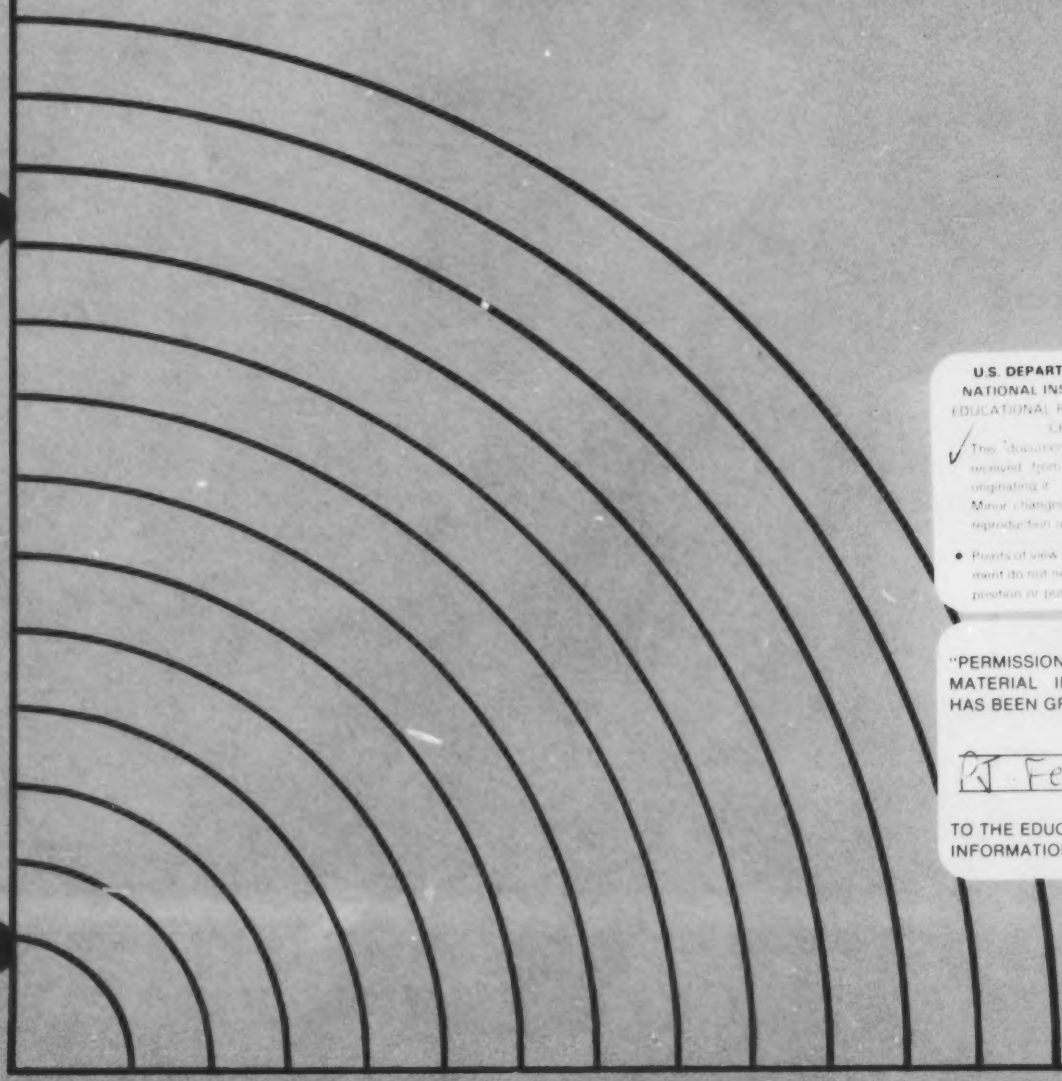
ALCOHOL FUEL

BY PRODUCT UTILIZATION AND PRODUCTION



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Preface

The curriculum presented in this booklet was written through the cooperative effort of faculty at the Canby and Granite Falls AVTI. Granite Falls AVTI had applied for a grant which would fund lessons on alcohol fuel plant processes and economics. A need for lessons in engine modification and plant design was seen during the development of this curriculum. Canby AVTI made application for funds to do the work on these subject areas. The materials and handouts included in this booklet are the results of the two grants. The course on Alcohol Fuels was first offered by these schools during the winter quarter of 1980.

This curriculum is divided into ten lessons. Each lesson contains objectives, student learning activities, class handouts, and references. An index includes a list of supplies and equipment needed to teach the course.

The subject of alcohol fuels is exposed to much debate. Training offered by Adult Vocational Education can provide a coordinated effort to answer questions on alcohol fuels and provide an objective look at alcohol as an alternative source of energy.

The purpose of this curriculum is to assist vocational teachers in establishing and conducting an alcohol fuels workshop.

Jim Boerboom
Project Coordinator
Granite Falls AVTI

Table of Contents

Glossary

Lesson 1	The Alcohol Fuel Plant	1
Lesson 2	Feedstock Preparation Lab.	5
Lesson 3	Distillation Lab.	15
Lesson 4	Fuel Plant Processes	21
Lesson 5	Plant Design Lab.	38
Lesson 6	Fuel Plant Earnings	53
Lesson 7	By-Product Uses	73
Lesson 8	Engine Modification (Spark ignition)	83
Lesson 9	Engine Modification (Diesel)	83
Lesson 10	Government Regulations and Permits	84
	Bibliography	93
	Audio Visual Aids	94
	Equipment and Supplies	96

GLOSSARY

Acidity	A measure of hydrogen ion concentration in a solution.
Alkalinity	A measure of OH ion concentration in a solution.
Alcohol	A group of organic compounds composed of carbon, hydrogen, and oxygen. Includes methanol, ethanol, ispropyl alcohol and others.
Alpha-Amylase	An enzyme that acts to accelerate hydrolysis of starch to dextrins.
Anaerobic	Without air. Fermentation is anaerobic.
Anhydrous	Without water. 100 percent alcohol or 200 proof.
Azeotrope	A term for two liquids at a certain concentration, boil at the same temperature. Alcohol and water cannot be separated more than 194.4 proof because at this concentration alcohol and water form an azeotrope and vaporize together.
Beer	The product of fermentation. Micro-organisms act on sugars to produce a 10-12% alcohol.
BTU	British Thermal Unit. The quantity of heat needed to raise one pound of water one degree Fahrenheit.
Biomass	Plant material including cellouse carbohydrates.
Boiling Point	The temperature at which a liquid boils.
Carbohydrate	Term describing compounds made up of carbon, hydrogen, and oxygen. Includes starches and sugars.
Carbon Dioxide	A gas produced as a by-product of fermentation: chemical formula is CO_2.
Cellulase	An enzyme capable of splitting cellulose.
Column	A vertical cylinder used to increase the degree of separation of liquid mixtures by distillation.
Condenser	A cooling apparatus designed to change vapor to a liquid by lowering the temperature.

DDGS	Distiller Dried Grains with Solubles. The residue left after fermentation and distillation. DDGS from corn contains about 27% protein.
Denaturant	A substance that makes ethanol unfit for human consumption.
Dextrins	An intermediate complex of sugars between starch and maltose formed by hydrolysis of starches.
Distillate	The end product of distillation.
Distillation	The process of separating two liquids by changing one to a vapor with heat and driving the vapor off a liquid. The separated vapor is then condensed.
Enzymes	Proteins which act as catalysts to change one chemical compound to another.
Ethanol	Ethyl alcohol or grain alcohol.
Fermentation	A process where yeast changes sugars to alcohol in the absence of air.
Gasohol	A blend of 90% unleaded gasoline and 10% anhydrous ethanol.
Glucose	A simple sugar that can be fermented to make ethanol.
Heat Exchanger	A device that transfers heat from one fluid to another.
Hydrometer	A long-stemmed glass tube with a weighted bottom; it floats at different levels depending on the relative wieght (specific gravity) of the liquid.
Methanol	Methyl alcohol or wood alcohol. (CH_3OH)
Methane	A gas produced from the decomposition of organic materials. (CH_4)
Mash	The prepared mixture for fermentation.
Proof	A measure of alcohol content. Proof is twice the percentage of alcohol.
pH	A measure of acidity or alkalinity on a scale of 0 - 14. The more acid a solution the lower the pH number. pH 7 is neutral; pH over 7 to 14 is alkaline.
Rectifying Column	The second column in a two column still.

Reflux	A liquid alcohol is returned to the distillation column to assist in increased conversion of higher proof alcohol.
Starch	A carbohydrate made up of long, tightly coiled chains of glucose molecules.
Stillage	The water and high-protein residue left after distillation.
Vaporize	To change from a liquid or solid to a vapor.
Yeast	A single-cell micro-organism (Fungi) that will produce alcohol and CO under aerobic conditions. Changes sugar to alcohol through fermentation.

The Alcohol Fuel Plant

Objectives:

1. To discuss the production and use of alcohol as a renewable fuel.
2. To discuss the operation of an alcohol fuel plant - a general overview.

Class Activities:

1. Tour an alcohol fuel plant.
2. View slides of alcohol fuel plants.

Lab Preparation:

1. Schedule plant tour.
2. Arrange transportation.

References:

1. Small-scale Fuel Alcohol Production Chapter VII.
2. Fuel From Farms - A Guide to Small Scale Ethanol Production. Chapter V, p. 47-70.
3. Makin it on the Farm, by Micki Nellis. Chapter III.

ALCOHOL

THE RENEWABLE FUEL

$$\text{SUN ENERGY} + \text{WATER} + CO_2 \longrightarrow \text{SUGAR} + O_2$$

PHOTOSYNTHESIS

$$\text{SUGAR} + \text{YEAST} \longrightarrow \text{ALCOHOL} + CO_2$$

FERMENTATION

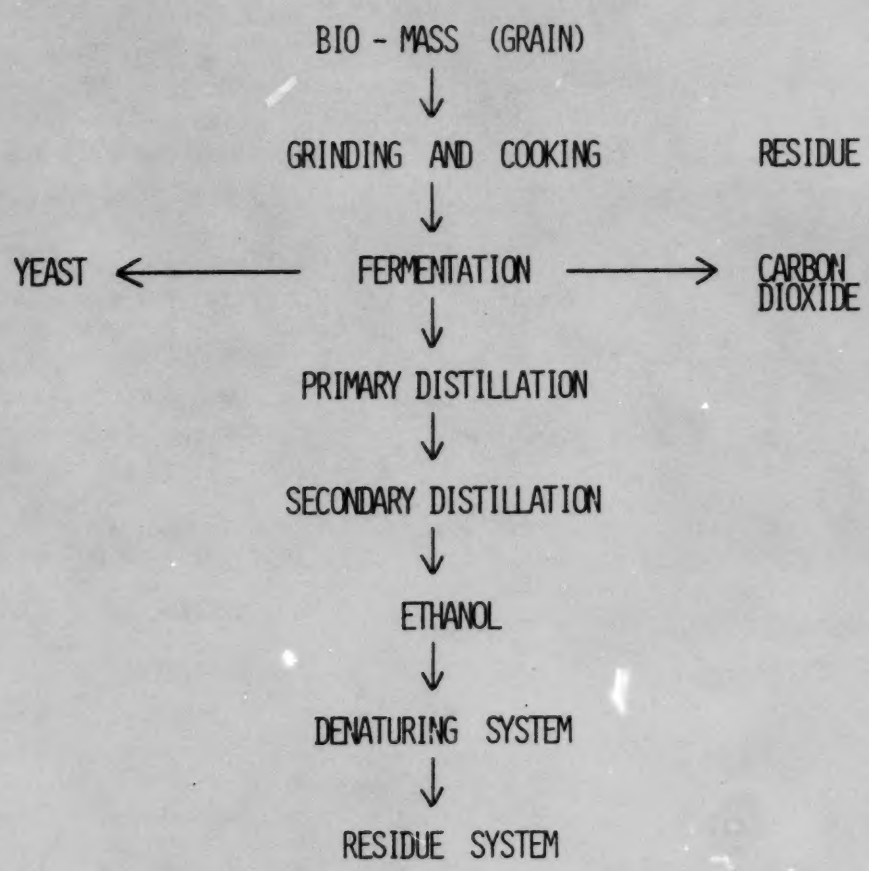
$$\text{ALCOHOL} + O_2 \longrightarrow CO_2 + \text{WATER} + \text{ENERGY}$$

COMBUSTION

SCHEMATIC DIAGRAM

OF

ALCOHOL PLANT



BASIC STEPS IN ALCOHOL PRODUCTION

1) **Milling** — The starch source (usually corn, wheat, rye or barley) is ground into a fine meal. This exposes the starch granules and permits suspension and dispersion in the following step.

2) **Slurrying** — Water is added to the meal to form a mash (typically 10-30 gallons of water per 56 lb. bushel of grain. pH is adjusted and liquefaction enzymes added.

3) **Liquefaction** — The mash is heated to gelatinize the starch (190-200°F) and render its susceptable to enzyme breakdown. The starch is converted into soluble high molecular weight sugars called dextrins.

4) **Conversion** — The mash is cooled to conversion temperature, (130-140°F). The pH is adjusted, and conversion enzymes are added. The mash is held long enough to permit some of the dextrins to be converted into fermentable sugars. It is then cooled further to fermentation temperature (85-90°F). Solids, at this point, should be 8-12% (about 30 gallons/Bu) so water can be added to aid cooling if high solids were used in the previous steps.

5) **Fermentation** — Distillers yeast is added and the mash is held 48-120 hours. During this time the conversion enzyme continues to break down dextrins to fermentable sugar while the yeast converts these sugars to alcohol and carbon dioxide. The fermentation process produces heat so that cooling is necessary to maintain yeast survival.

6) **Distillation** — The fermented mash is heated to vaporize the alcohol and the vapors are collected and cooled to condense the alcohol back to a liquid. The residue contains the residual grain, spent yeast and water. The residual grain and spent yeast are generally used in animal feeds. The water is usually recycled.

Feedstock Preparation Lab

Objectives:

1. To prepare various feedstocks used in making alcohol fuels (milling).
2. To process feedstocks for conversion of starch to sugar (slurrying and liquefaction).
3. To prepare feedstock for fermentation. (Conversion and fermentation).

Class Activities:

1. Complete Lab exercise in mashing and cooking feedstocks.
2. Add yeast to prepared feedstock and let ferment 2-3 days in preparation for distillation lab.

Lab Preparations:

1. Supplies for group of 4:

   #10 Can
   Stir Stick
   thermometer
   bunsen burner or hot plate
   feedstock
   pH paper
   acid
   base
   enzymes
   yeast

References:

1. Fuel From Farms - A Guide to Small Scale Ethanol Production, Chapter III.
2. Small-Scale Fuel Alcohol Production, Chapter IV.
3. Making Alcohol Fuel, Lance Crombie; p. 27-37.
4. Makin' it on the Farm, Micki Nellis, Chapter V, p. 27-29.

MILES RECIPE

FOR

The Production of Alcohol

(Lab. exercise)

1. Obtain the 315 gram corn sample from the instructor.

2. Pour the sample into the #10 can, stir-in 800 ml. (Milliliters) of water.

3. Check the pH, it should be between pH 6.0 - 6.5. If it is not, adjust the pH by adding Sulfuric Acid (H_2SO_4) or Sodium Hydroxide (NaOH) a base while checking the solution with pH indicator paper.

4. Add 0.3 ml.of Taka-therm, an alpha-amylase enzyme, from the buret and mix well.

5. With continuous stirring heat slowly to 194°F (90°C). The mixture will thicken (gelatinize) as the starch granules start to absorb moisture (at 162°F, 72°C).

6. Hold the mixture at 194°F for 30 minutes. Stir continuously. The enzyme will start to break up (Hydrolyse) the long starch molecules into shorter pieces. These pieces are actually sugars (dextrins) of varying length and complexity. This also causes the mixture to to become thinner. NOTE: IF YOU FORGET TO ADD THE ENZYME, OR GET THE pH OUTSIDE OF THE WORKING RANGE OF THE ENZYME, THE MIXTURE WILL CONTINUE TO THICKEN INTO A PASTE AND WHEN IT COOLS IT WILL BE SOMEWHERE BETWEEN LIBRARY PASTE AND JELLO IN THICKNESS. . .

7. Bring the mixture to a boil 100°C (212°F) at sea level. ADD WATER AS REQUIRED TO PREVENT SCORCHING. Boil for about 10 minutes. NOTE: The actual cooking time should be varied so as to completely cook the starch, therefore a large grind of a hard, flinty texture corn would require more cooking than a fine grind of a soft field corn.

8. Cool the mixture to 130°F (54°C); recheck the pH (it should be between pH 6.0 - 6.5) and add another 0.3 ml. of TAKA-THERM enzyme.

9. Finish cooling the mixture to 130°F (54°C) by adding enough cold water to bring the total volume up to 1 liter (1,000 ml.).

10. Adjust the pH to pH 4.0 - 4.5 by adding about 3.0 ml. of dilute Sulfuric Acid ($3N_2H_4SO$) from the buret. Check the pH with the pH paper.

11. Add 1.5 ml of DIAZYME L-100. The optimum temperature for this enzyme is between 120° and 130°F (49° - 54°C). This enzyme starts at one end of each complex sugar and cuts it at each alpha-1, 4 linkage. Everytime this occurs a glucose (dextrose) is released. Glucose is a simple sugar and yeast loves it!! for food.

12. Continue to stir and hold the mixture at 130°F (54°C) for 30 minutes. Check a small sample with the iodine test solution (Lugol's solution). A BLUE COLOR THAT DOES NOT FADE UPON MIXING INDICATES THAT STARCH IS STILL PRESENT (+ TEST). A COLORLESS RESULT INDICATES THAT ALL THE STARCH HAS BEEN CONVERTED TO SIMPLE AND COMPLEX SUGARS. Ask the instructor if you have any questions.

13. Add water as required to bring the total volume up to 1 liter. Cool to 80 - 90°F (27-32°C) which is the optimum temperature for yeast fermentation of simple sugars to alcohols. NOTE: pH 4.5 is the optimum pH for yeast.

14. Add cake yeast (not dry or frozen) about 36 grams NOTE: this is excess yeast the extra large inoculum is to greatly decrease the fermentation time to fit the time constraints of this lab exercise. This is a Baker's yeast (Saccaromyces cerevisiae). Mix well and ferment for 2 - 2½ days at 80 - 90°F (27 - 32°C). This yeast is capable of producing a 10 - 12% alcohol solution from a 20 - 24% sugar solution.

14. Cover your can and lable it with the name of your group members.

BIOCON RECIPE

FOR

The Production of Alcohol

(Lab. exercise)

Atmospheric Cooking:

1. Obtain 315 gram. sample.
2. Pour sample into #10 can, stir in 800 ml. of water.
3. Check pH, it should be 6.0 to 6.5.
4. Add 0.5 gram of Canalpha a liquifying enzyme.
5. With continuous stirring heat to 194°F (90°C). The mixture will thicken as the starch granules start to absorb moisture.
6. Hold at 200°F (94°C) for 15 minutes stirring continuously. (The enzyme will start to break up the long starch molecules in shorter pieces. These shorter pieces are sugars called dextrins.)
7. Cool the mixture to 150-170°F (65° - 75°C) by adding water; check pH it should be 6.0 - 6.5.
8. Add another .5 gram of enzyme Canalpha.
9. Hold at 150-170°F (65° - 75°C) for 30 minutes, mixing constantly.
10. Adjust pH to 4.0 - 4.5 by adding about 18 ml. of dilute sulfuric acid (H_2SO_4).
11. Cool to 90°F (32°C) quickly as possible. Add .5 gram of Gasolase enzyme. The optimum temperature for this enzyme is 90°F (32°C).
12. Add 0.5 g. distillers yeast. Mix well.
13. Cover your can and label it with name of your group members.

MILES RECIPE

FOR

The Production of Alcohol

1. Milling — The starch grain (corn, wheat, rye, barley) is ground into a fine meal.

2. Slurrying — Water is added at the rate of 10 gallons/1 bu. of corn. Check pH, adjust to 6.0 - 6.5.

3. Liquification — Add Takatherm at the rate of 1 oz./1 bu. or corn.

(The enzyme breaks starch into large sugars - dextrins).

4. Conversion

a) Heat mixture to 200°F, hold for 30 minutes.
b) Continue heating to 212°F or 250°F.
c) Cool to 190° F by adding 2 Gallons water/1 bu. corn.
d) Add more Takatherm.
e) Hold at 190°F for 20 minutes.
f) Cool to 140°F by adding 4 gallons of water/bu. corn.
g) Adjust pH to 4.0 - 4.5 by adding Sulfuric acid.
h) Add 4 oz. of Diazyme - L - 100 and hold for 20 min.
i) Add 14 gallons of water/1 bu. corn to cool mixture to 85° F.
j) Add yeast at the rate of ½lb./1 bu. of corn.
k) Stir occaisionally during fermentation.

Note: Temperatures above 90°F during fermentation encourage bacterial growth which converts glucose to acetic acid.

5. Fermentation — Distillers yeast is added and the mash is held 48-120 hours. During this time the conversion enzyme continues to break down dextrins to fermentable sugar while yeast converts these sugars to alcohol and carbon dioxide. The fermentation process produces heat so that cooling is necessary to maintain yeast survival.

6. Distillation — The fermented mash is heated to vaporize the alcohol and the vapors are collected and cooled to condense the alcohol back to a liquid. The residue contains spent yeast and water. The water may be recycled.

BIOCON (U.S.) INC.

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Technical and Product Information

BIOCON'S

SIMPLE "4" STEP PROCEDURE

For 5 Bushels*

Step I.	Add water to cooker (20 gal/bushel) Add 5 bushels corn or other cereal ground as fine as possible. Add 2 oz. CANALPHA (white powder). Mix well. Heat to 200 - 212°F with constant mixing. Hold for 15 minutes.
Step II.	Cool mash to 150 - 170°F by adding just sufficient water (5 gal/bushel). Add 4 oz. CANALPHA (white powder). Mix well. Hold for 30 minutes with constant mixing.
Step III.	Cool mash to 90°F as fast as possible. Add 2 oz. GASOLASE (fine brown powder). Add 4 oz. BIOCON Special Distiller's Yeast (granulated brown powder). Mix well. Ferment 2 - 3 days.
Step IV.	Mash now ready for distillation.

With experience the above rates may be reduced by as much as 50 - 60% without loss of yield. With reduced rates and purchasing CANALPHA, GASOLASE, AND BIOCON Special Distiller's Yeast in quantity the cost per gallon of 180 proof alcohol will be around 8 - 10¢. If yeast price is not included the cost will be 2 - 3¢ lower.

*For quantities other than 5 bushels adjust rates accordingly.

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Technical and Product Information

PROCESS FOR USING GASOLASE AND CANALPHA IN PRODUCTION OF GASOHOL

The following is a simple description of how Biocon enzymes can be used in the production of Gasohol from potatoes. The details may vary depending on equipment available. Biocon are pleased to offer advice where necessary.

ATMOSPHERIC COOKING:

(1) Slice potatoes.

(2) Add the potatoes to water at 100-160°F. Use up to 50 gallons per 100 lbs. of potatoes, as little water as is necessary to make mash mobile. Mix well.

(3) Add 1/2 lb. Canalpha per 2000 lbs. potatoes. Mix well.

(4) Raise the temperature to 200°F to boiling (212°F) with live steam injection or by use of steam coils.

(5) Hold at high temperature for 15-30 minutes.

(6) Cool to 165-170°F by adding water. Mix well.

(7) Adjust PH to about 5.6.

(8) Add 1 lb. Canalpha per 2000 lbs. Hold for 30 minutes. Cool to 90-100°F. Mix well.

(9) Add distiller's yeast (3 lbs./1000 gals.) and Gasolase (3/4 lb/2000 lbs. potatoes)

(10) Ferment until saccharometer reading remains constant for 6 hours. The addition of 1/4 lb. of Lofoam per 2000 lbs. will control foaming.

(11) The mash is now ready for distillation.

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Technical and Product Information

PRESSURE COOKING

(1) Add potatoes to Cooker. No water is necessary.

(2) Raise steam pressure in about 25 minutes for 0 to 60 lbs.

(3) Raise steam pressure in about 13 minutes for 4 to 90 lbs.

(4) Hold for about 25 minutes.

(5) Release pressure.

(6) Cool mash down to 160-170°F. Mix well.

(7) Adjust PH to about 5.6. Mix well.

(8) Add Canalpha at the rate of 0.05% (1 lb./2000 lbs. potatoes). Mix well.

(9) Hold for 15 minutes or until liquid.

(10) Cool mash down to below 100°F. Mix well.

(11) Add distiller's yeast plus Gasolase at rate of 0.04% (3/4 lb. Gasolase/2000 lbs. potatoes). Mix well.

(12) Ferment until saccharometer reading remains constant for 6 hours. The addition of 1/4 lb. of Lofoam per 2000 lbs. will control foaming.

(13) The mash is now ready for distillation.

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SUMMARY OF FEEDSTOCK CHARACTERISTICS

Type of Feedstock	Processing Needed Prior to Fermentation	Principal Advantage(s)	Principal Disadvantage(s)
Sugar Crops (e.g., sugar beets, sweet sorghum, surgarcane, fodder beet, Jerusalem artichoke).	Milling to extract sugar.	1. Preparation is minimal. 2. High yeilds of ethanol per acre. 3. Crop coproducts have value as fuel, livestock feed, or soil amendment.	1. Storage may result in loss of sugar. 2. Cultivation practices are not wide-spread, especially with "nonconventional" crops.
Starch Crops: Grains (e.g., corn, wheat, sorghum, barley) Tubers (e.g., potatoes, sweet potatoes)	Milling, liquefaction, and saccharification.	1. Storage techniques are well developed. 2. Cultivation practices are widespread with grains. 3. Livestock coproduct is relatively high in protein.	1. Preparation involves additional equipment, labor, and energy costs. 2. DDG from aflatoxin-contaminated grain is not suitable as animal feed.
Cellulosic: Crop Residues (e.g., corn stover, wheat straw) Forages (e.g., alfalfa, Sudan grass, forage sorghum.	Milling and hydrolysis of the linkages.	1. Use involves no integration with the livestock feed market. 2. Availability is widespread.	1. No commercially cost-effective process exists for hydrolysis of the linkages.

13

Table VII-2. Comparison of process factors of other feedstocks to corn

	Storage length of seam	Feedstock preparation	Sugar extraction	Cooking hydrolysis	Fermentation	Distillation	Dehydration	By-product processing
Corn	grain bins 12 months	grind	none	heat and hydrolyze	with solids	2 columns	Benzene extraction	DDGS or wet stillage
Wheat	grain bins 12 months	grind	none	heat and hydrolyze	same	same	same	DDGS or wet stillage
Milo/sorghum	grain bins 12 months	grind	none	heat and hydrolyze	same	same	same	DDGS or wet stillage
Sweet sorghum	piles 3 months	crush in roller mill	separate sugar & fiber	none	liquid only	larger size	liquid only	low value fiber
Sugar cane	piles 3 months	crush in roller mill	separate sugar & fiber	none	liquid only	larger size	liquid only	low value fiber
Sugar beets	piles 4 months	slice	extensive extraction	none	liquid only	larger size	liquid only	beet pulp dry or wet
Potatoes	controlled atmosphere 12 months	grind	none	heat and hydrolyze	same	somewhat larger size	same	potato pulp dry or wet
Starch	bins 12 months	none	none	heat and hydrolyze	same	same	same	yeast only
Molasses	tanks 12 months	none	none	none	same	same	same	yeast only

14

U.S.D.A. Publication - Small-Scale Fuel Alcohol Production

Distillation Lab

Objectives:

1. To define distillation.
2. To compare physical properties of water and alcohol.
3. To describe equipment used for distillation.
4. To distill alcohol.

Class Activities:

1. Complete distillation lab.
2. Test proof of ethanol.
3. Run lab engine of distilled alcohol.

Lab Preparation:

Supplies for a group of 4:

- Mash separation (nylon sock)
- Flask for beer
- Distillation column
- Heat source
- Condensor
- Fuel storage
- Thermometer
- Water supply

References:

1. Fuel From Farms - A Guide to Small Scale Ethanol Production, Chapter III, p. 35-38.
2. Small-Scale Fuel Alcohol Production, Chapter IV, p. 11-12.
3. Making Alcohol Fuel, Lance Crombie, p. 49-55.
4. Makin' It on the Farm, Micki Nellis, Chapter VI, p. 32-34.

Distillation can be defined as driving vapor from a liquid by heating and then condensing the vapors.

Alcohol turns to a vapor at 173°F. Water remains a liquid until it reaches 212°F. However, ethanol does not boil off at 173°F. Alcohol and water hold on to each other tightly.

To break up the water-alcohol partnership, a distillation column is used. Perforated trays are spaced throughout the column. Alcohol "beer" enters near the middle of the column and steam enters at the bottom. The beer flows down through holes in the plates as the steam rises, vaporizing the alcohol and some of the water.

The hottest plate is the bottom one. As the alcohol and water vapors rise and come into contact with cooler and cooler plates, the water vapors condense and run down the column. The alcohol vapors, which remain in a gaseous state until they are cooled to 173°F, continue to rise. By the time the vapors reach the top plate, most of the water vapors have condensed.

All of the uppermost vapors are condensed and collected in a storage container. Some of this condensed, the reflux, must be piped back into the column to get the high-proof alcohol distillers want.

BASIC ALCOHOL MANUFACTURING INFORMATION

Properties of:	Water	Ehtanol
Chemical Formula:	H_2O	CH_3CH_2OH
Molecular Weight	18.015	46.07
Weight of 1 gallon:	8:33 lb.	6.59 lb. (100%) 6.80 lb. (95%)
Density in Grams/cm^3:	1.0	.791 - 100% (200 proof) .815 - 95% (190 proof)
Surface Tension in Dynes/cm^2:	54.9 @ 40°C	21.38 @ 40°C
Freezing and Melting Point:	0° C (32° F)	-117.3° C (-178.6° F)
Boiling Point:	100°C (212° F)	78.5°C (173.3°F)
Heat of Vaporization:	1100 BTU's/lb. @ 212°F 9155.5 BTU/gal.	378.13 BTU's/lb. @ 173.3 F 2491.8 BTU/gal.
Critical Temperature:	374.2° C	243° C
Heat of Combustion		327.6 Cal/Kg.

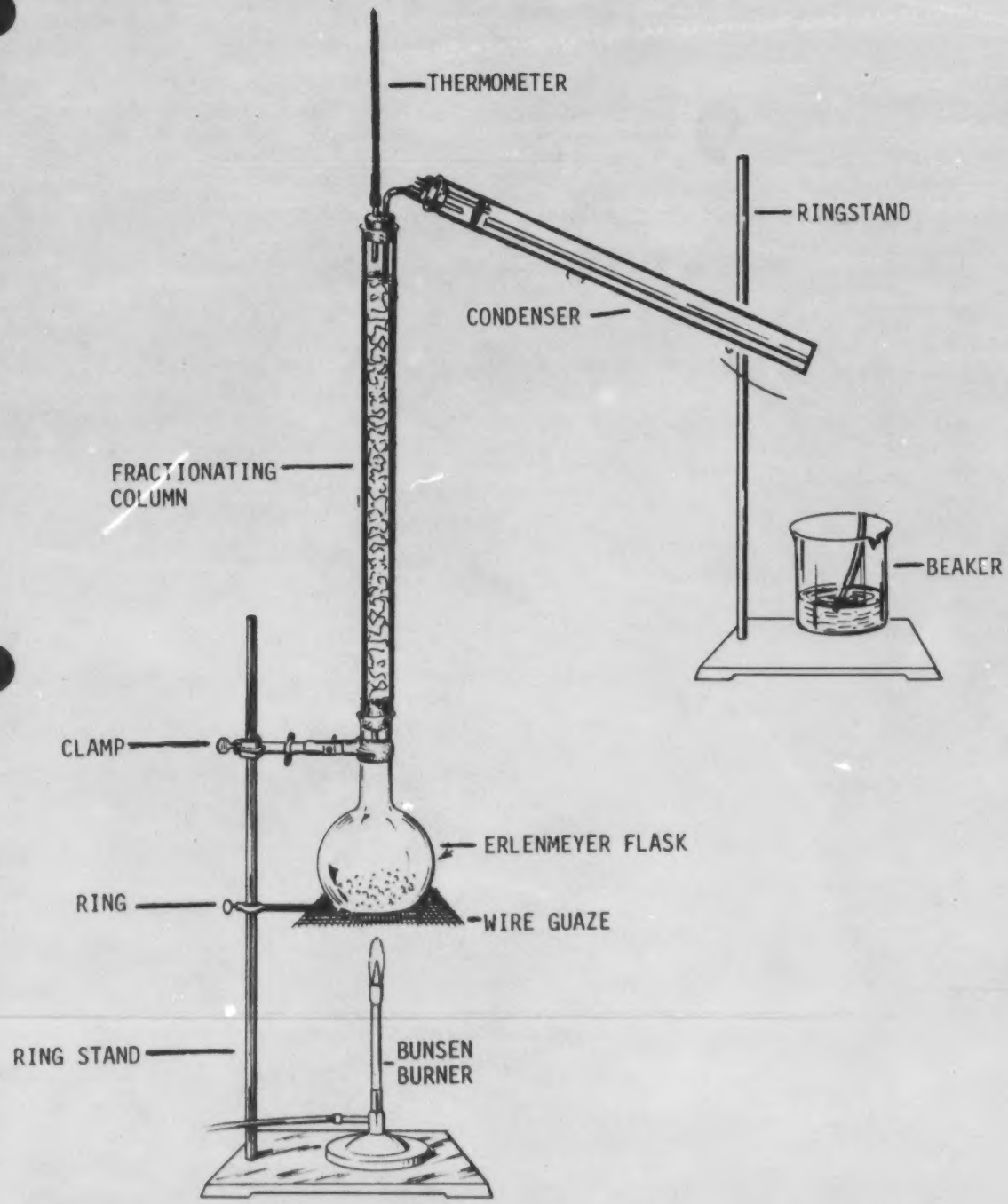
Distillation Lab Procedure

Apparatus:

1. Two ring stands and clamps.
2. Bunsen burner or hot plate.
3. Flask for beer (100 ml. or larger)
4. Fractionationating column.
5. Thermometer inserted through cork or rubber stopper and placed on top of fractionationating column.
6. Adaptor from column to condenser.
7. Condenser.
8. Flask or graduated cylinder to catch distillate.

Procedure:

Set up apparatus as shown in the diagram. When a hot plate is used as a heat source, the beer flask should be placed into a water bath. This provides a uniform heat around the beer flask. When a bunsen burner is used a chimney on the burner may provide more uniform heating.


THERMOMETER
RINGSTAND
CONDENSER
FRACTIONATING COLUMN
BEAKER
CLAMP
ERLENMEYER FLASK
RING
WIRE GUAZE
RING STAND
BUNSEN BURNER

Success in fractional distillation is dependent upon very careful adjustment of the rate of heating.

The fractionating column located above the beer flask can be packed with glass beads or stainless steel sponge. The column packing provides a cooling space for water vapor to condense and trickle downward. The packing also allows open air space for ethanol vapors to rise through the column.

Equilibrations occur along all parts of the column and vapor that eventually passes to the top of the column should be a high proof product provided the temperature is held at (173^{o}F) 78.5^{o}C.

Ethanol vapor at the top of the distillation column will continue to move through to the condenser. A cold water jacket circulating through the condenser will condense the ethanol vapor.

If the percent of beer in the flask is estimated to be 10 percent, you can expect to get about 10 ml. of 180 proof for every 100 ml. of beer.

It is impossible to separate all the ethanol from the water. As distillation continues the water-ethanol mixture forms an azeotrope and will vaporize at the same temperature.

At the conclusion of the lab a recommended class activity is to collect the distilled ethanol; measure proof with a hydrometer; and run an engine on the alcohol fuel produced in the lab.

Plant Process Discussion

Objectives:

To compare yields of various feedstock materials.

To describe the processes of cooking, fermentation, and distillation.

To define pH.

To describe the role of enzymes in the conversion process.

To describe the action of yeasts in fermentation.

Class Activities:

Complete worksheet on plant processes.

View slides on action of yeasts and enzymes.

Answer questions on plant processes.

References:

1. Fuel From Farms - A Guide to Small Scale Ethanol Production, Chapter III and IV.
2. Small - Scale Fuel Alcohol Production, Chapter IV and V.
3. Making Alcohol Fuel, by Lance Crombie Ps. 11 - 57.
4. Makin' It On the Farm, by Micki Nellis, Chapter II and V.

III YIELD STATISTICS

FEEDSTOCK	ALCOHOL YIELD	PROTEIN MEAL	PROTEIN CONTENT (% OF DRY WEIGHT)
CORN	2.73 GAL/BU (190 PROOF) 2.55 GAL/BU (200 PROOF)	18 LB/BU	29-30%
WHEAT	2.6 GAL/BU (AVERAGE)	20.7 LB/BU	36%
GRAIN SORGHUM	2.6 GAL/BU	16.8 LB/BU	29-30%
STARCH GRAINS	2.5 GAL/BU	17.5 LB/BU	27.5%
POTATOES (75% MOISTURE)	1.4 GAL/CWT	14.8 LB/CWT	10%
SUGAR BEETS	20.3 GAL/TON	264 LB/TON	20%
MOLASSES (50% SUGAR)	68 GAL/TON	—	--

FUEL PROPERTIES

FUELS	BTU/GAL.	WT. LGS./GAL.	OCTANE NO. (ROAD)
ETHYL ALCOHOL	84,000	6.7	97.5
UNLEADED GASOLINE	125,000	6.1	87.2
REGULAR GASOLINE	124,000	6.1	88.0
GASOHOL 10% ETHYL ALCOHOL 90% GASOLINE	120,900	6.15	90.5
PROPANE	92,000	4.25	100
DIESEL FUEL #2	140,000	7.0	CETANE NO. 40-55

GALLONS OF ETHYL ALCOHOL AND BY-PRODUCT PRODUCED FROM VARIOUS RAW MATERIALS

MATERIAL	GAL. OF ETHYL ALCOHOL/UNIT	BY-PRODUCT PRODUCED (LB/UNIT)	TOTAL PROTEIN CONTENT OF BY-PRODUCT (%)
WHEAT (BUSHEL)	2.6	20.7	32
CORN (BUSHEL)	2.6	16.8	27
SORGHUM (BUSHEL)	2.6	16.8	27
POTATOES (CWT.)	1.4	14.8 (75% MOISTURE BASIS)	10
SUGARBEETS (TON)	20.3	264	10
MOLASSES (GALLON)	.4	15.6 (75% MOISTURE BASIS)	10

Making Alcohol Fuel

A. Energy Efficiency

1. About 3% of the total United States energy consumption goes for production of farm commodities.

2. Adding in transportation, storage, packaging, sales, home storage, and cooking, the total is about 16%.

3. In the crop production segment:
   a. 10% - 15% field operations
   b. 30% - 38% fertilizer
   c. 16% crop drying
   d. 6% - 13% irrigation
   e. 2% - 5% pesticides
   f. 2% machinery manufacture
   g. 15% - 20% Miscellaneous uses

4. International Economy - Trade
   a. Agricultural exports - $27 billion/year
   b. Oil Imports - $44.5 billion/year
   c. Using 3% of the total United States energy supply, agriculture is able to make up for more than half of the money we spend to import oil plus supply all of the food and fiber we need for our domestic market.

5. An "Energy take-off" Example
   a. Nitrogen fertilizer
      1. Natural gas is needed for a source of H_2.
      2. Natural gas or some other fuel is needed to combine this hydrogen with nitrogen from the air to produce ammonia.
      3. Nearly 40,000 cubic feet of natural gas to produce a ton of ammonia.
      4. 5 Tons of ammonia applied to a corn crop will produce enough food to meet the minimum energy and protein needs for 275 persons for one year.
      5. If the energy needed to produce the 5 tons of ammonia were instead used to heat a home, it would do just that - heat only one home for one winter.

B. Renewable and Non-Renewable Resources

1. Non-renewable
   a. Coal
   b. Petroleum
      1. Other uses include; fertilizer, plastics, cosmetics, pharmaceuticals, rubber goods, synthetics, etc.

2. Renewable
   a. Green plants and their products and by-products.

B. 3. Economics
   a. Coal (plant matter) and petroleum (animal matter)
      1. It took many years to produce a ton of coal or a barrel of petroleum and only a very short time to use it up.
      2. Amounts of supply of these non-renewable resources are finite.
   b. Use renewable resources as the main energy source and the non-renewable resources only where the renewable resources cannot be used.

C. Basics

1. $6\ CO_2 + 6\ H_2O + \text{Energy}$ (growing degree days - or calories), $\xrightarrow[\text{chlorophyll}]{\text{sunlight}} C_6H_{12}O_6 + 6\ O_2\uparrow$

   Carbon dioxide + water + energy $\longrightarrow$ sugar + oxygen
   (Photosynthesis)

2. $C_6H_{12}O_6 + 6\ O_2 \longrightarrow 6\ CO_2 + 6\ H_2O + \text{energy}$
   sugar + oxygen $\longrightarrow$ carbon dioxide + water + energy
   (respiration)

3. $C_6H_{12}O_6 \xrightarrow{\text{yeast}} 2\ C_2H_5OH + 2\ CO_2\uparrow$
   sugar $\longrightarrow$ ethyl alcohol + carbon dioxide
   (fermentation)

Yield of Alcohol

Sugar $\longrightarrow$ Ethanol + Carbon Dioxide

$C_6H_{12}O_6 \longrightarrow 2\ C_2H_5OH + 2\ CO_2$

C = 12
H = 1
O = 16

$C_6H_{12}O_6 \longrightarrow 2\ C_2H_5OH + 2\ CO_2$
180 $\longrightarrow$ 92 + 88

180 lbs. $\longrightarrow$ 92 lbs. + 88 lbs.

So: One lb. of sugar $\longrightarrow$ ½ lb. alcohol + ½ lb. CO_2

Yield of Alcohol

Bushel of corn = 56 lbs.

Corn = 72.2% carbohydrate (Sugars & Starches)

Sugar = 72 lbs. sugar in 100 lbs. of corn

$$\text{Sugar} = \frac{72}{100} \times 56 \text{ lbs.} = 40 \text{ lbs. of sugar}$$

40 lbs. of sugar $\longrightarrow$ 20 lbs. of alcohol + 20 lbs. CO_2

Density of alcohol = 6.6 lbs./gallon

$$\begin{array}{r} 6.6 \text{ lbs.} \\ \times\ 3.05 \text{ gal./Bu.} \\ \hline 20.13 \text{ lbs.} \end{array}$$

at 20° c or 65° F

$$6.6 \overline{)\,20}\ \ 3.05 \text{ gal./Bushel (theoretical)}$$

56 lbs. of pure sugar 4.2 gallons of 200 proof ROH

$$\frac{\text{lbs. of sugar}}{15} = \text{gallons of alcohol}$$

D. Raw Materials

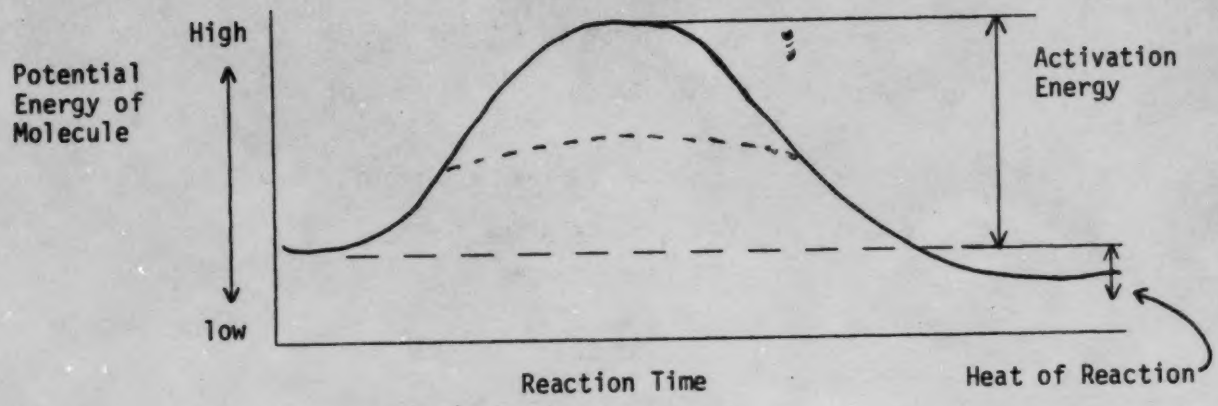
1. Sugar Crops - sugar beets, sugar cane, green chop grasses, etc.
   a. Have fermentable sugars at harvest time.
      1. Require little preprocessing, no enzymes, and give high alcohol yields per acre.
   b. Disadvantages maybe cost of production or storage.

2. Starches - grain, potatoes, vegetables, etc.
   a. Require some method to break down the long chains of sugar molecules by heat, enzymes, acids or micro-organisms.

3. Cellulose - corn stalks, hay, straw, wood, newspaper, etc.
   a. Hardest to break down into simple sugar. Requires specific enzyme, strong acid, or certain micro-organisms for this.

37

Enzyme as a Catalyst



= Catalyst (enzyme)

Fermentation

Using Yeast

$$C_6H_{12}O_6 \xrightarrow[\text{zynose}]{\text{yeast}} 2\ CO_2 + 2\ C_2H_5OH$$

Using Sprouted Grain

$$(C_6H_{12}O_5) + H_2O \xrightarrow[\text{sprouted grain}]{\text{diastose}} C_{12}H_{22}O_{12} \xrightarrow[\text{maltose}]{\text{yeast}} 2\ C_6H_{12}O_6 \xrightarrow{\text{fermentation}}$$

Starch — Maltose — Glucose

$$2\ C_2H_5OH + CO_2$$

Alcohol — Carbon Dioxide

38

E. Fermentation

1. Keep the conditions anoerobic.
   a. When excessive air (O_2) is present the yeast will produce acetic acid (vinegar).

2. 48 Hours of fermentation of the mash is an average time to produce fuel alcohol.

3. Fermentation residue.
   a. Contains unused starch, proteins, vitamins, minerals, fats, and yeast cells.
   b. Called distillers dried grains and solubles.
   c. Show transparency on DDG from corn.

4. Warning - don't drink the products of fermentation.
   a. Yeast fermentation of sugar to alcohol conversion produces not only alcohol and carbon dioxide but other organic chemicals such as butanol, propanol, aldehydes and ketones. Pathogenic organisms may also be contaminating the mash.
   b. If the alcohol is produced in containers other than copper, stainless steel, or glass the chemical reaction between the base metals and the alcohol produces poisonous by-products.

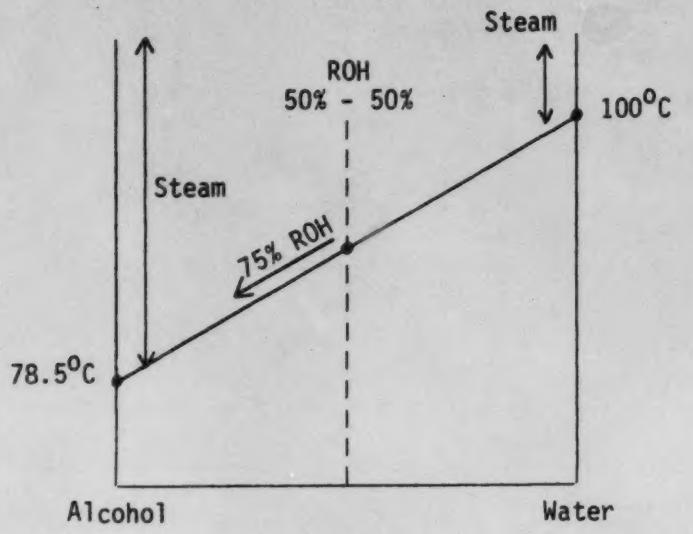
F. Distillation

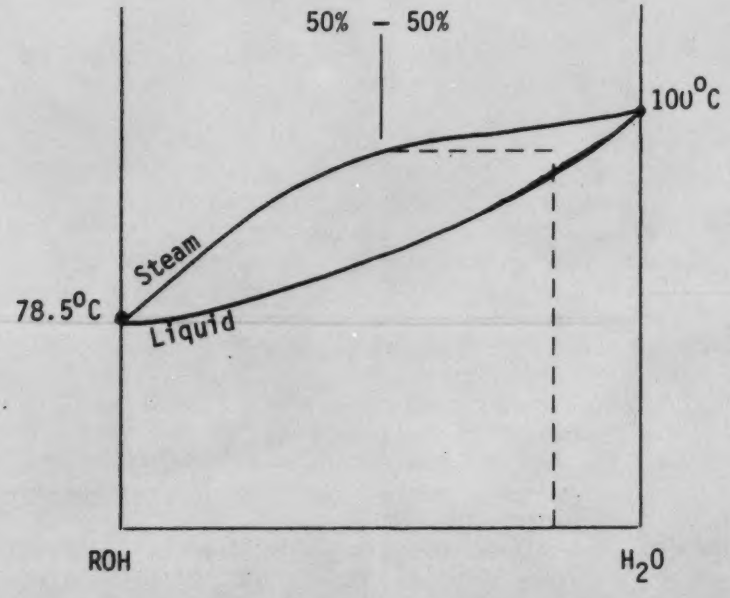
1. Distilling is to separate the alcohol from the water by vaporizing them because of the differences in boiling points.

2. End product (alcohol) purity is called proof.
   a. Simple distillation will not produce high proof alcohol but is simple and cheap to operate.
   b. Reflex distillation produces high quality (190 proof) alcohol but is more costly to operate.

3. 200 Proof Alcohol
   a. Alcohol for gasohol should be 197-200 proof.
   b. Making 200 proof from 190 proof or less;
      1. Azeotropic distillation
         a. Organic solvent such as benzene is co-distilled with alcohol.
         b. Special column and equipment are required.
      2. Salt extraction.
         a. Water dissolves in salt but alcohol does not.
         b. Examples of salts are phosphates, sulfates, calcium salts, fertilizers and dry cellulose can be used to absorb the water.
   c. Alcohol for Alcohol Fuel does not have to be 190-200 proof.

Fractional Distillation = different volatility of 2 or more substances.





The less volatile substance will condense first.

CARBON DIOXIDE

Application In Its Use

1. Beverage Industry
   a. Carbonated water
2. Fresh Meat Processing and Shipping
   a. 4 to 6 lbs. of CO_2 pellits/100 lbs. of meat
   b. Inhibits bacteria growth, weepage and shrinkage
   c. Chills the meat
   d. Prevents discoloration of meat by O_2.
3. Poultry Processing & Shipping
   a. Same as for other meats.
4. Frozen Food (meats, bakery goods, ice cream,etc.)
   a. Same as for fresh meats.
5. Fire Protection
   a. Fire extinguisher
6. Greenhouses
   a. Added to atmosphere to help photosynthesis.
7. Welding
   a. Used as a shielding agent of the weld zone on welding electrodes.
8. Municipal Water Treating
   a. Used in the process of softening hard water.
9. Low Temperature Testing
   a. Liquid CO_2 is used or dry ice for testing components
10. Hardening of sand cores and molds used in casting metals.
11. Shrink Fitting
    a. Its cooling potential is used to shrink machined metal parts to produce a tight fit.

12. Packaging and Storing

    a. Replacing O_2 in sealed packages or preasure packed cans, CO_2 creates an atmosphere that prevents deterioration and loss of flavor.

13. Fresh Fruit and Vegetable Shipment

    a. O_2 content is reduced and CO_2 content is increased in the atmosphere of highly perishable fresh fruits & vegetables. Allows the product to maintain its "freshness".

14. Grain Storage (Proposed)

    a. Send CO_2 through grain bin

        1. Will reduce moisture %
        2. May destroy any living insects found within the grain mass.
        3. May help grain maintain its "freshness" by reducing respiration rate by replacement of O_2 with CO_2.

Feedstock Byproducts

A. Brewers dried grains - The residue which remains after most of the starches and sugars have been removed from the grain feedstock.

B. Distillers feeds = Dealcoholized Whole Stillage

1. High in protein.
2. Rich in water-soluble vitamins and minerals.
3. Excellent sources of GFF (grain fermentation factors) which stimulate growth and rumen function.
4. They are highly digestible.

1. Condensed Distillers Solubles - Obtained after removal of alcohol by distillation by condensing the thin stillage fraction to a semisolid or syrup.

2. Distillers Dried Solubles - Obtained after removal of alcohol by distillation by condensing the thin stillage fraction and drying it.

3. Distillers Dried Grains - Obtained after removal of alcohol by distillation by separating the resultant coarse grain fraction of the whole stillage and drying it.

4. Distillers Dried Grains with Solubles - Obtained after the removal of alcohol by distillation by condensing and drying at least 3/4 of the solids of the resultant whole stillage. It is estimated that DDGS contain 6% - 12% yeast cells. (GFF Source?) For proper storage the moisture content of these byproducts should be between 8% and 12%. Heating and mold damage can occur if the moisture content exceeds 15.9%.

   Distillers Dried Solubles has hygroscopic (water attracting) tendencies and should be packaged in moisture proof bags and have a moisture content of about 5% and stored in a cool, dry location.

Nutrient Composition of Distillers Feeds

The nutrient makeup of distillers feeds is related closely to the composition of the cereal grains used. The influence of raw materials and processing that may affect composition are the following factors:

Raw materials

1. Kind of cereal grain
2. Variety of grains
3. Quality of grains
4. Grain formula or mash bill.
   a. % of grains (1 or more) and malt.

ALCOHOL FUEL PLANT PROCESSES

The classes of Feedstocks that may be used for the preparation of alcohol include:

1. Sugar crops
2. Starch crops
3. Cellulose crops

Identify the class that each of these feedstocks belongs to:

_____ Sugar Beets

_____ Corn stalks

_____ Potatoes

_____ Apples

_____ Corn grain

Name the biological catalyst that helps reduce starch to sugar:

_____

Compare the alcohol yield for these feedstocks:

Feedstock	Yield
Corn	_____gal./bu.
Wheat	_____gal./bu.
Potatoes	_____gal./cwt.
Sugar beets	_____gal./cwt.

Grains should be prepared for cooking by milling or grinding. Why is this recommended?_____

_____

_____

The percent of hydrogen is measure by "pH" on a scale of 1 to 14. Match the pH number to the correct description:

	pH
_____ Nuetral	2
_____ Acid	6
_____ Very acid	7
_____ Very alkaline	12

Why is pH adjusted to 4.0 - 4.5 previous to fermentation?_____

_____

What acids can be used to lower pH? _____

_____

What bases can be used to raise pH? _____

_____

Name two methods which can speed up the cooking process?

_____

_____

Sprouted grain may be used to introduce enzymes into the mash. What percent of malt (sprouted grain) is necessary to convert starch to sugar?

_____

Water weighs _____ lbs. per gallon.

Ethanol weighs _____lbs. per gallon.

Calculate the percent alcohol and water for each proof reading:

Proof	% Water	% Ethanol
200	___	___
160	___	___
100	___	___
20	___	___

FERMENTATION

What do yeast look like?_____

_____

Yeast should be added at _____ percent dry starch basis.

The fermentation process removes carbohydrates while protein remains. What is the expected percent of total protein in mash? _____

DISTILLATION

Name three methods of distillation:

1. _____
2. _____
3. _____

What temperature does water vaporize? _____ ^{o}F _____ ^{o}C

What temperature does ethanol vaporize? _____

Reflux is defined as return or "flow back". This can be used to control temperature at the top of a distillation column. Explain how this is done:

Write the chemical equation for photosynthesis:

Write the chemical equation for fermentation:

Write the chemical equation for ethanol combustion:

Name the products of ethanol combustion that are consumed in the process of photosynthesis.

_____

_____

_____

One bushel of corn processed for fuel alcohol yields what amount of product:

_____ gallons ethanol

_____ pounds CO_2

_____ pounds of mash

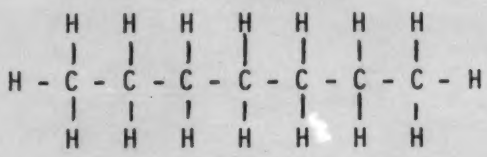
Chemistry Notes

Rule of Solubility: Like disolves like -

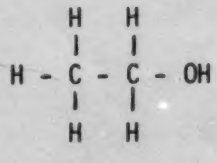
- Polar likes polar
- Non-polar likes non-polar
- Polar hates non-polar

Gasoline and water do not mix due to polarity or arrangement of molecules.

Gasoline (C_7H_{16}) is non-polar or straight.

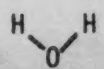


Ethanol (C_2H_5OH) is non-polar or straight.



47

Water (H_2O) is polar or bent.



Plant Design Lab

Objectives:

1. To identify feedstock storage facilities.
2. To identify feedsotck preparation facilities.
3. To identify plant components used in cooking, fermentation, and distillation.
4. To build a table-top model of an alcohol fuel plant.
5. To draw a flow chart of an alcohol fuel plant process.

Class Activities:

1. Build a table-top model of an alcohol fuel plant, label all component parts, and complete plumbing hook-ups.
2. Draw a flow chart for an alcohol fuel plant.

Lab Preparation:

References:

1. Fuel From Farms - A Guide to Small Scale Ethanol Production, Chapter V.
2. Small-Scale Fuel Alcohol Production, Chapter VII.
3. Making Alcohol Fuel, Lance Crombie, P: 59-70.
4. Makin' It On the Farm, Micki Nellis, P: 36-40.

CHECK LIST

FOR

FARM SIZE STILLS

A. _____ Water

1. 25 - 30 gallons/gallon alcohol/day
2. Storage Tank and Pump

B. _____ Land

C. _____ Buildings - space for:

1. Boiler _____
2. Cooking _____
3. Fermentation _____
4. Distillation _____

D. _____ Storage - Facilities for:

1. Enzymes _____
2. Yeast _____
3. Chemicals _____
4. Boiler fuel _____

E. _____ Feedstock Preparation

F. _____ Feedstock Transfer

G. _____ Boiler

1. Supply process heat _____
2. Treatment facilities _____

H. _____ Cooking Tank

1. Size = 15 gallons/bu. + 25%
2. Bottom coned _____
3. Agitator _____
4. Heat source _____
5. Transfer pump _____
6. Heat required =

$$\text{Gallons of mash} \times 8.3 \times \frac{150}{\text{hrs. to heat}}$$

I. _____ Fermentation Tank

1. Size = 30 gallons/bu. + 25%
2. CO_2 vent and air trap _____
3. Cooling coils _____
4. Agitation _____
5. Transfer pump _____
6. Bottom coned _____

J. _____ Instrumentation

1. PH meter or indicator _____
2. Temperature indicator
   a. Cooking _____
   b. Fermentation _____
   c. Distillation _____
3. Temperature Controllers _____
4. Hydrometer _____
5. Starch Tester _____
6. Sugar Tester _____

K. _____ Distillation and Rectification

1. Beer well _____
2. Stripper column _____
3. Rectifying column _____
4. 3/16 Tube wall or 12 gauge _____
5. Packing or plates _____
6. Liquid level indicator in stripping column _____
7. Reflex pump _____
8. Reflex Temperature Sensor and Control _____
9. Condenser _____
10. Pressure Guage _____
11. Safety valve _____
12. Column Temperature Indicators _____
13. Provision for Cleaning _____

L. _____ Denaturing

1. 1 Gallon gasoline per 100 gallons of alcohol.
2. Other means acceptable to BATF

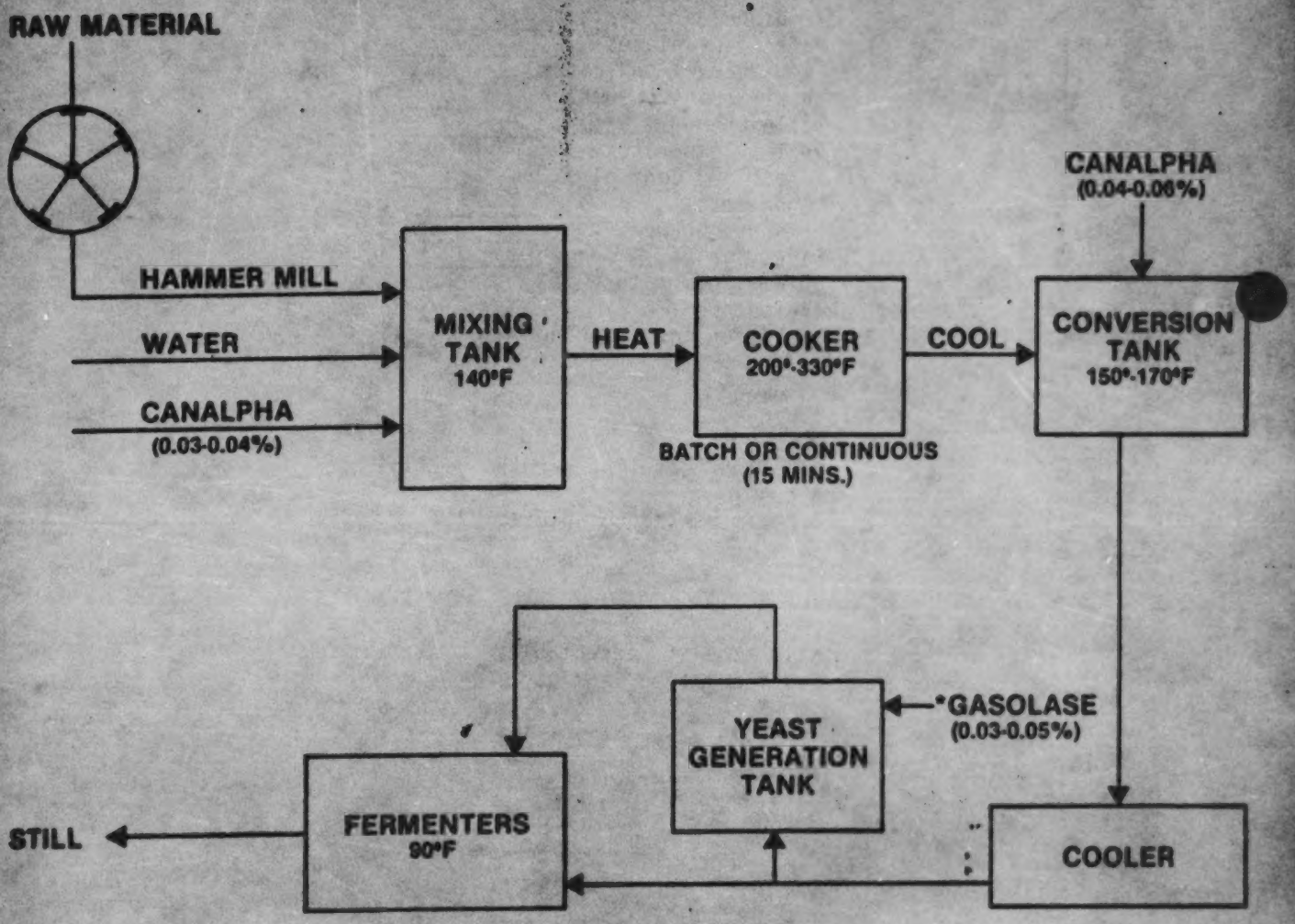
M. _____ Storage

1. Mild steel is acceptable.
2. Dessicant type vent cap.

N. _____ Residue

1. Store _____
2. Feed _____

BIOCON
ENZYME CONVERSION PROCESS
(CORN, RYE, WHEAT & POTATOES)



*IN ABSENCE OF YEAST GENERATION TANK GASOLASE CAN BE ADDED DIRECTLY TO FERMENTER.

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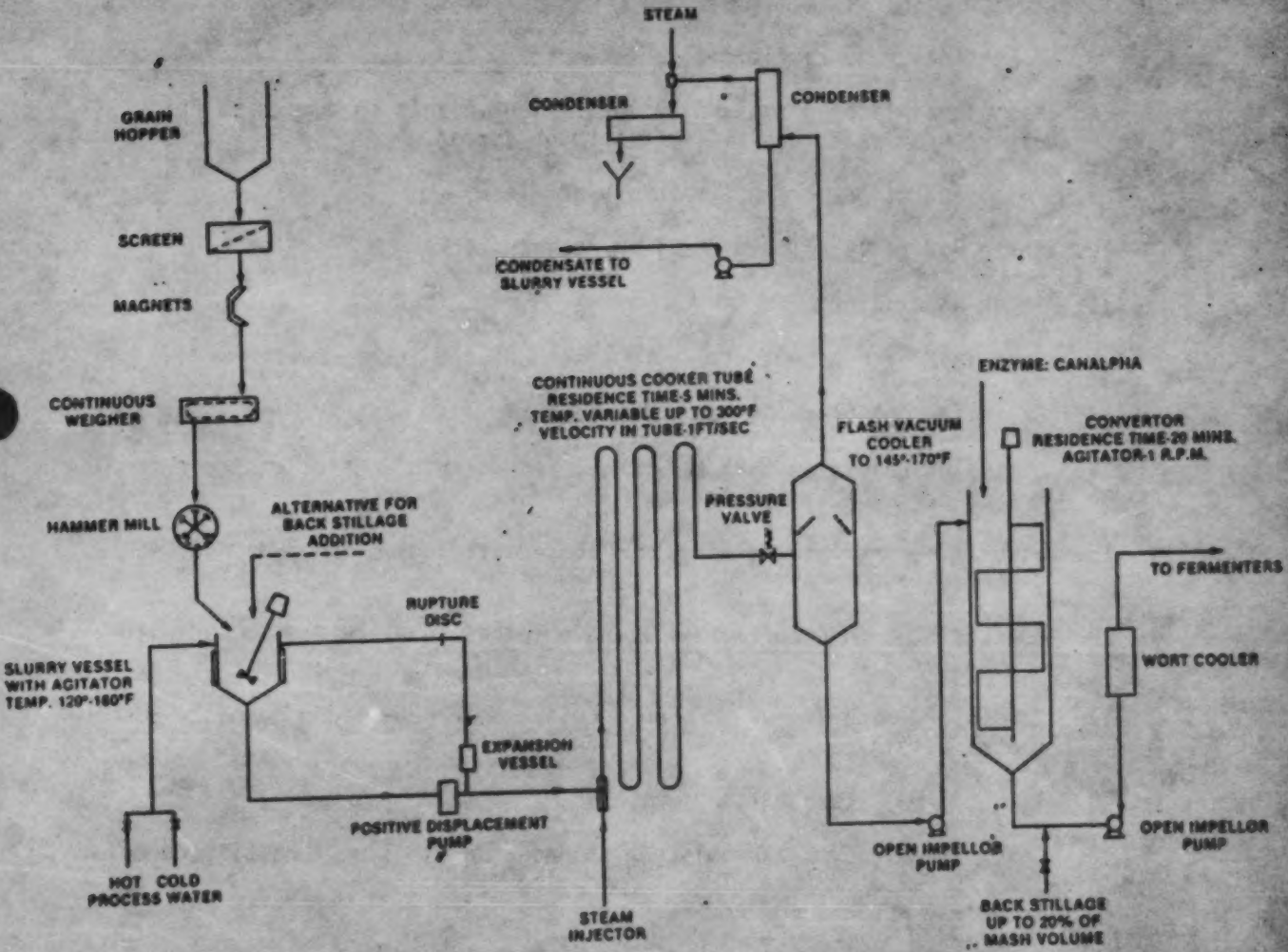
PROPOSED SCHEME FOR CONTINUOUS WHOLE MASH COOKING



42

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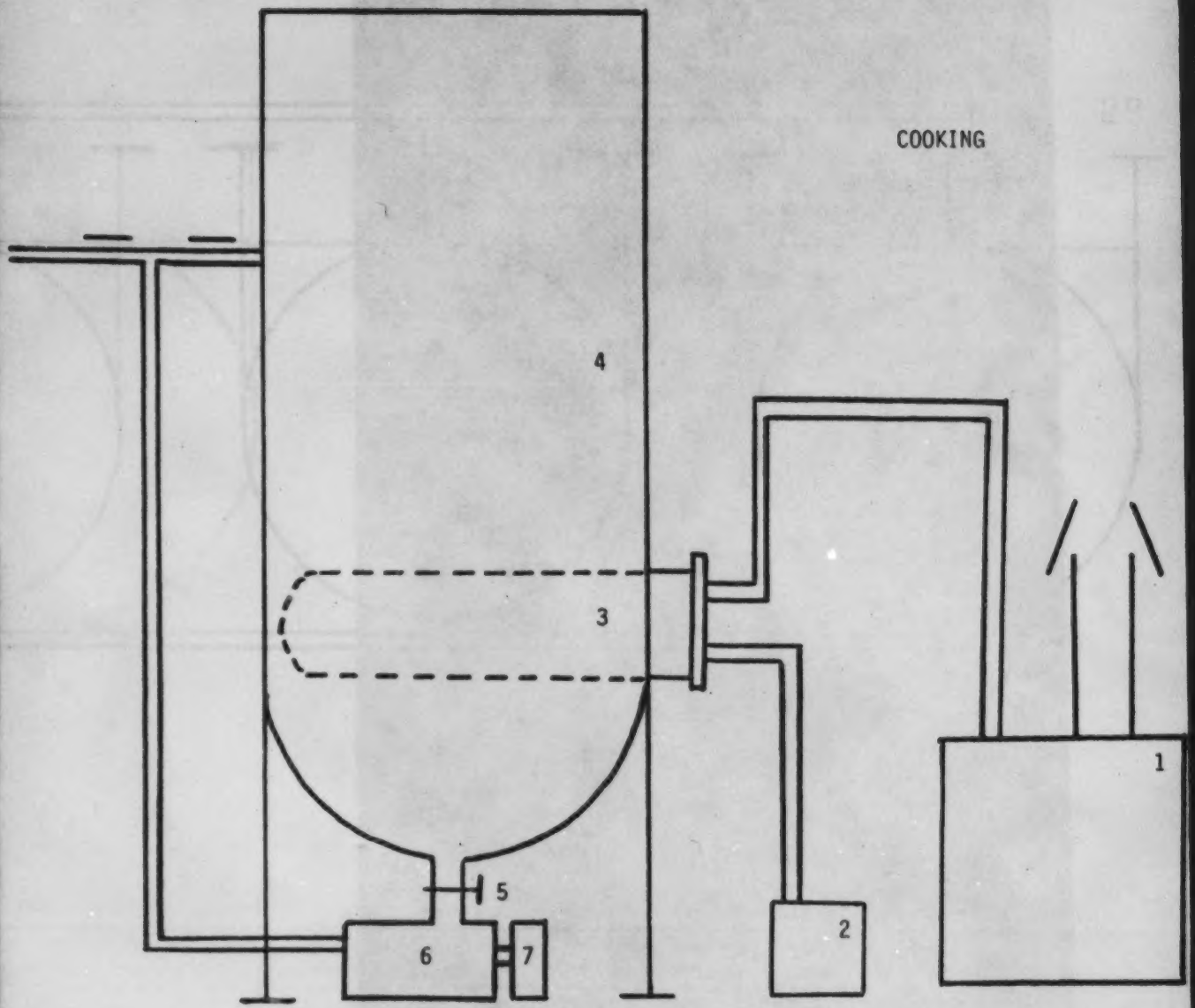
GRANITE FALLS AVTI
DISTILLATION PLANT

1. 5 horsepower low pressure steam boiler - 200,000 BTU's per hour.
2. Condensate pump.
3. Tube bundle heat exchanger.
4. 500 gallon L.D. Tank shell.
5. 3 inch ball valve.
6. 40 gallon/minute positive displacement pump used for agitation and moving mash.
7. 3 horsepower hydraulic motor.
8. Mash separation unit stand on legs. Tank pivots to dump mash out after sugar water has filtered through screen.
9. Mash separation screen (grain drying floor).
10. Three 400 gallon fiberglass fermentation tanks.
11. Sugar water line.
12. Beer line into top of stripping column passed through water well.
13. Beer line out of fermentation tanks.
14. Stripping column 10 feet tall and 6 inches in diameter; packed with ½ inch ceramic burle saddles.
15. Vapor line from stripping column to rectifiying column. Made of 4" diesel exhaust pipe.
16. Rectifying column 10 feet tall and 6 inches in diameter; packed with ½ inch ceramic burle saddles.
17. Condenser; water flows through a 6 inch outer shell and condense alcohol vapors passing through a 4 inch inner shell.
18. Alcohol fuel storage tank.
19. Reflux pump: pumps alcohol from storage tank to top of rectifying column.
20. Temperature guage and probe.
21. Solenoid valve: allows reflux to flow to top of rectifying column.
22. Pump: removes condensate from bottom of rectifying column and returns to top of stripping column.
23. Pump: removes water that has condensed at the base of the stripping column


COOKING
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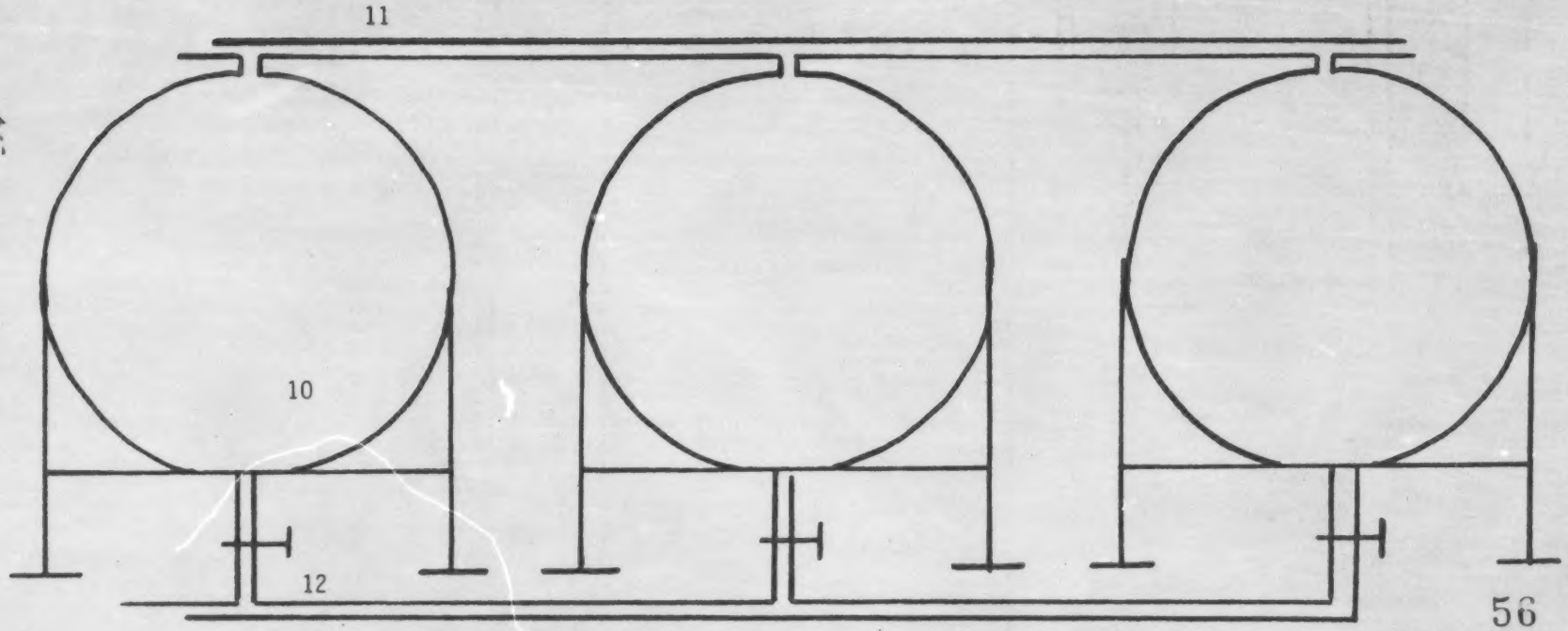
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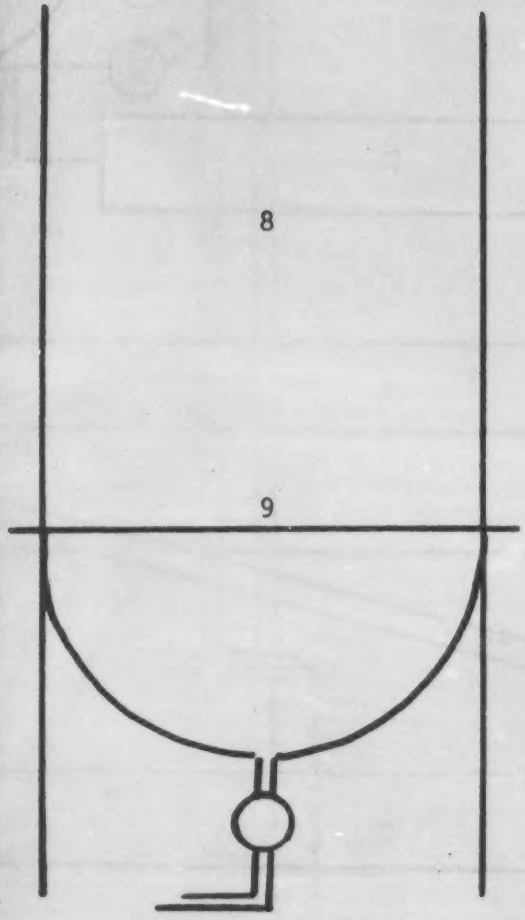
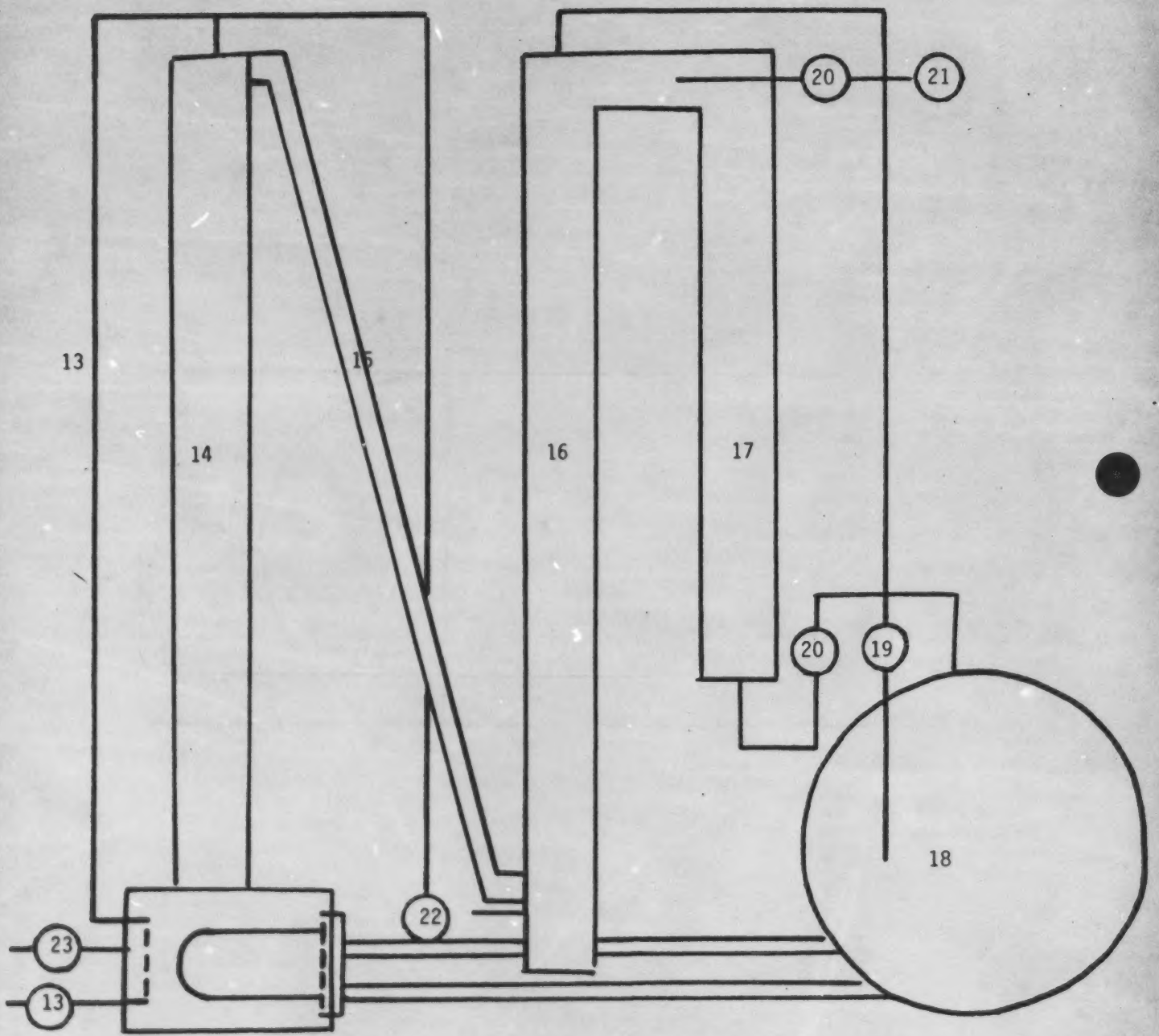
55

MASH SEPARATION



DISTILLATION



HYDRAULIC MOTOR SIZING

by

Jim Fischer
Fluid Power Department
Granite Falls AVTI

GIVEN: 3 HP. at 155 R.P.M.

$$HP = \frac{\text{Torque (inch lbs)} \times \text{R.P.M.}}{63025}$$

$$\text{Torque} = \frac{HP \times 63025}{\text{R.P.M.}}$$

$$\text{Torque (in. lbs.)} = \frac{3 \times 63025}{155}$$

Torque = 1,219.8 IN. LBS.

Hydraulic Motors are rated in displacement (Cubic inches per revolution)

Before the next step can be completed the operating pressure of the hydraulic power unit is determined.

We will assume it to be 1,000 PSI in the following calculations:

$$T = \frac{PSI \times \text{Displacement}}{6.28} \times \text{Mech. EFF}$$

T = Torque in Inch Lbs.

PSI = Pounds per Square Inch

Disp. = Cubic In./Rev.

Mech. EFF = Mechanical Efficiency (loss due to internal friction). This is available from motor manufacture . We will use .85 or 85% EFF as given to us by manufacturer of this motor.

$$\text{Disp.} = \frac{T \times 6.28}{PSI \times \text{Mech. EFF}}$$

$$\text{9 Cu. In. Disp.} = \frac{1219.8 \times 6.28}{1{,}000 \times .85}$$

So the motor size would be 9 Cu. In., if this size was not available I would have to select one close to 9 Cu. In. and recalculate my new operating pressure.

For Example: 8 Cu. In. Disp.

$$PSI = \frac{T \times 6.28}{Disp. \times Mech.\ EFF}$$

$$PSI = 1{,}126.5$$

If a hydraulic motor is starting under full load, multiply Mech. EFF x starting efficiency. A hydraulic motor does not have full torque available at start up. Starting EFF usually ranges from 60% to 80% of running torque.

Example: 1219.8 In. Lbs.
8 Cu. In. Disp.

$$PSI = \frac{T \times 6.28}{Disp. \times Mech.\ EFF \times Startup\ EFF}$$

$$PSI = \frac{1219.8 \times 6.28}{8 \times .85 \times .7}$$

$$PSI = 1609.3$$

Determining Flow:

$$GPM = \frac{Disp. \times R.P.M.}{231 \times Volumetric\ Efficiency}$$

GPM = Flow - Gallons per minute
RPM = Speed - revolutions per minute
DISP = Cu. In./Rev.
Volumetric EFF = Loss due to internal fluid slippage, this is available from Manufacturer. We will use .9 or 90% Vol. Eff.

$$GPM = \frac{Disp. \times R.P.M.}{231 \times Vol.\ EFF.}$$

$$GPM = \frac{8 \times 155}{231 \times .9}$$

$$GPM = 6$$

The hydraulic pump would have to produce 6 GPM.

HP into Hydraulic Motor:

$$HP = \frac{GPM \times PSI}{1714}$$

$$HP = \frac{6 \times 1{,}126.5}{1714}$$

HP = 3.9 HP into Hydraulic Motor

Pump Sizing

Total all flows that will be run at one time.

Pump will be selected based on that flow rate at a given R.P.M. (Speed of Electric Motor)

HP to Drive Pump

$$HP = \frac{PSI \times Flow\ (GPM)}{1714 \times Overall\ EFF.}$$

HP = HP to drive pump

PSI = Pressure - relief valve setting.

GPM = Flow - maximum

Overall EFF = Loss of power due to slippage and friction, available from pump manufacturer. We will use 85% in these calculations.

$$HP = \frac{1600 \times 20}{714 \times .85}$$

HP = 22 HP input to pump

BOILER CAPACITIES

HORSE POWER OUTPUT	6	8	11	14	17	20	24	32	42	55
1,000 BTU's PER HOUR	250	330	450	575	700	825	1000	1320	1750	2300

HEAT = ENERGY

1 KCAL RAISES 1 KG. OF WATER 1°C.

1 BTU RAISES 1 LB. OF WATER 1°F.

1 CAL RAISES 1 GRAM OF WATER 1°C.

TABLE V-1 HEAT SOURCE SELECTION CONSIDERATIONS

HEAT SOURCE	HEATING VALUE (DRY BASIS)	FORM	SPECIAL EQUIPMENT REQ'D	BOILER TYPES	SOURCE	PARTICULAR ADVANTAGES	PARTICULAR DISADVANTAGES
Agriculture Residuals	3,000-8,000 BTU/lb.	Solid	Handling and feeding eqpmt; collection equipment.	Batch burner-fire tube; fluidized bed.	Farm	Inexpensive; produced on-farm.	Low bulk density; requires very large storage area.
Coal	9,000-12,000 BTU/lb.	Solid	High sulfur coal requires stack scrubber	Conventional grate-fire tube; fluidized bed.	Mines	Widely available demonstrated technology	Potentially expensive: no assured availabilit pollution problems
Waste Wood	5,000-12,000 BTU/lb.	Solid	Chipper or log feeder	Conventional fluidized bed	Forests	Clean burning; inexpensive where available	Not uniformly available
Municipal Solid Waste	8,000 BTU/lb.	Solid	Sorting Equipment	Fluidized bed or conventional fire tube.	Cities	Inexpensive	Not widely available in rural areas.
Pyrolysis Gas		Gas	Pyrolyzer-fluidized bed.	Conventional gas-boiler.	Carbon-aceous materials	Can use conven-tional gas-fired boilers.	Requires additional piece of equipment.
Geothermal	N.A.	Steam/ Hot water	Heat exchanger	Heat exchanger water tube	Geother-mal source	Fuel cost is zero.	Capital costs for well and heat exchanger can be extremely high.
Solar	N.A.	Radia-tion	Collectors, concentrators, storage batteries, or systems.	Water tube	Sun	Fuel cost is zero.	Capital costs can be high for required equipment.
Wind	N.A.	Kinetic energy	Turbines, storage batteries, or systems.	Electric	Indirect solar	Fuel cost is zero.	Capital costs can be high for required equipment.

Fuel From Farms, P: 50.

Fuel Plant Earnings

Objectives:

1. To identify market pathways for alcohol fuels and distilled grains.
2. To identify fuel plant operating costs.
3. To compare capital equipment costs.
4. To compare returns from farm and commercial use of alcohol fuels.
5. To evaluate return from fuel by-products.

Class Activities:

1. Complete worksheet titled Alcohol Fuel Operating Costs.
2. Complete worksheet titled Crop Returns.

References:

1. Fuel From Farms - A Guide to Small Scale Ethanol Production, Chapter II and VI.
2. Small-Scale Fuel Alcohol Production, Chapter VIII, P: 1-16.

What does it cost to produce a gallon of alcohol fuel? The answer to this question will depend on many factors. The processing of a crop into alcohol fuels can be compared to the processing of a gallon of milk. The cost of capital is variable and operating costs change with each individual.

This section of the course will address the economics of small scale on farm alcohol fuel production. Included in this section is a financial analysis of the on-farm still.

Arguments made for on-farm processing of feedstocks into alcohol fuels include:

1. Reduce transportation costs of feedstock from the field to the plant.
2. Direct feeding of spent grains to livestock, and
3. Elimination of drying costs of residue.

Production costs of a gallon of ethanol (grain alcohol) is dependent on plant size as shown in Figure 1.

Factors affecting production costs are listed on the worksheet titled Earnings Worksheet - Alcohol Fuels. According to Don Fink, U.S.D.A., plants producing 25 - 30 gallons of ethanol per hour may be the most efficient. However, size of the plant is best determined by each individual.

An alcohol fuel plant may be built for a single farm or a group of farmers. The size of plant may be determined by (1) annual fuel use (2) the number of days plant will operate and (3) options in using the mash. The worksheet titled Alcohol Fuel Plant Feasibility will assist individuals in determining size of fuel plants.

The decision to produce alcohol fuel may follow steps 1-11 as outlined.

I. List equipment that may be converted to alcohol fuels.

A. Gasoline Engines

1. Total conversion using 160-200 proof at 100 percent of fuel needs.

Equipment	Number of Gallons
a. _____	_____
b. _____	_____
c. _____	_____
d. _____	_____

2. Conversion using 200 proof alcohol as gasohol at 10 percent of fuel.

Equipment	Number of Gallons
a. _____	_____
b. _____	_____
c. _____	_____
d. _____	_____

B. Diesel Engines

1. Conversion using 100-140 proof as an air injected system at 20 percent of fuel need.

Equipment	Number of Gallons
a. _____	_____
b. _____	_____
c. _____	_____
d. _____	_____

2. Conversion using 100-140 with dual injection pump at 50 percent of fuel need.

Equipment	Number of Gallons
a._____	_____
b._____	_____
c._____	_____
d._____	_____

C. Grain Drying

	Number of Gallons
1. L.P. Fired Dryer	_____

a. 92,000 BTU's/Gallon-L.P.
b. 84,000 BTU's/Gallon-etoh

2. Fuel Oil Fired Dryer	_____

a. 140,000 BTU's/Gallon-#2 diesel
b. 84,000 BTU's/Gallon-etoh

II. Calculate number of gallons of alcohol equipment would use.

A. Gasoline Engines	_____
B. Diesel Engines	_____
C. Grain Drying	_____
Total	_____

III. Determine size of fuel plant needed to meet needs considering

A. Number of days plant will operate.

B. Hours per day plant will operate.

C. Plant output in gallons per hour.

IV.

Column Size	Distillation Rate in Gallons/Hour
16"	40
12"	22 - 30
8"	10 - 12
6"	8
4"	6

V. Consider Fuel Storage Needs

VI. Calculate size of processing equipment to match output of distillation column.

A. Cook Tank 15 gallons/bu. + 25%

B. Fermentation 30 gallons/bu. + 25%

VII. Calculate size of Boiler for:

A. Cooking

1. $\frac{\text{Gallons of mash} \times 8.3 \times 150}{\text{hours to heat}}$

2.

B. Distillation

1. 400 BTU's per lb. of ethanol

2. 6.6 lbs./gallon of ethanol

VIII. Calculate bushels of feedstock used each day in alcohol Fuel Plant.

IX. Calculate amount of feed by-product produced from feedstocks.

X. Determine livestock numbers that could be fed residue.

Class of Livestock	Mash Fed
Dairy or beef cow	7 lbs/head/day
Feeder cattle	5 lbs/head/day
Hogs	2.5-3 lbs/head/day

XI. Calculate costs and returns for feedstocks processed for alcohol fuels.

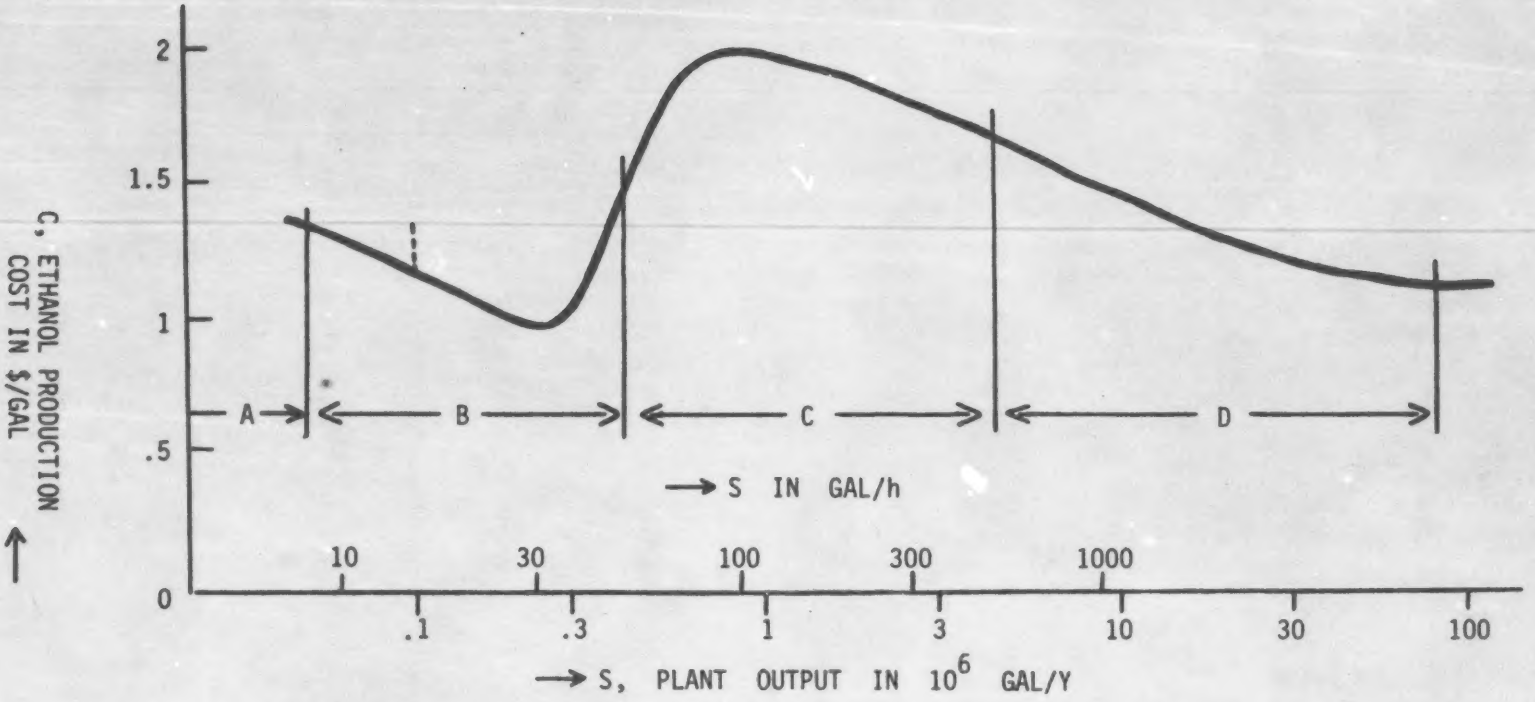


FIG. 9 ETHANOL PRODUCTION COST VS. PLANT SIZE REGIONS:

A. NON-ECONOMIC UTILIZATION OF A PLANT WHICH IS TOO SMALL TO JUSTIFY ITS CAPITALIZATION AND THE TIME SPENT TO "FOOL AROUND WITH IT".

B. THOSE SMALL SYSTEM PLANTS WHERE THE FARMER OR NEIGHBORS USE THEIR OWN GRAIN AND FEED THEIR OWN CATTLE WITH THE WET MASH.

C. THE TRANSPORTATION COSTS RISE AND PART OF THE MASH NOW NEEDS TO BE DRIED. THESE PLANTS ARE RELATIVELY LARGE BUT NOT LARGE ENOUGH TO TAKE ADVANTAGE OF ECONOMIES OF SCALE OR SPECIAL SITING.

D. ECONOMIES OF SCALE, SITING FOR RESOURCES AND MANPOWER HELP TO LOWER THE COST.

ACCORDING TO DON FINK, U.S. DEPARTMENT OF AGRICULTURE, SEPTEMBER, 1979.

EARNINGS WORKSHEET

Alcohol Fuels

I. Capital Investment

A. Cost of Still _____

B. Years of Life _____

C. 20% 1st Year Depreciation _____

Annual Capital Costs = $\frac{\text{Cost of Still - 20\% 1st Year Depreciation}}{\text{Estimate Years of Life}}$

Annual Capital Costs = _____

Annual Capital Per Gallon = _____

II. Operating Costs

A. Labor

_____ Dollars per hour

_____ Hours per day

_____ Distillation Rate in Gallons per Hour

Labor = $\frac{\text{Dollars per Day}}{\text{Gallons Alcohol/Day}}$ = _____

B. Energy to cook and distill one gallon of 190 proof alcohol.

Heat Exchanges	No Heat Exchanges	
_____	_____	Gallons fuel oil at $_____/gallon
_____	_____	Cubic ft. Natural Gas _____/cu. ft.
_____	_____	Gallons L.P. at $_____/gallon

Energy Cost per gallon of Alcohol = _____

C. Feedstock

1. Corn $_____/bushel
2. Sugarbeets $_____/ton
3. Potato $_____/ton
4. Other $_____/_____

Corn yielding _____gallons/bu.

Sugarbeets yielding _____gallons/ton

Potatoes yielding _____gallons/ton

Cheese whey yeilding _____gallons/ton

_____ x _____ = $_____/gallons

Example:

$\frac{2.00}{1 \text{ bushel}}$ x $\frac{1 \text{ bu.}}{2.5 \text{ gallons}}$ = $.80/gallon

Annual Feedstock = $_____/year

D. Water $.004/gallon of alcohol

E. Enzymes $.10 - .20/gallon of alcohol

F. Yeast $.004/gallon of alcohol

G. Lime $.004/gallon of alcohol

H. Acid $.01/gallon of alcohol

I. Denaturant $.05/gallon of alcohol

J. Interest

1. Rate of Interest _____%
2. Amount Borrowed _____
3. Years of Payment _____

Year	Debt Payment	Debt		Rate of Interest		Annual Interest
1			X		=	
2			x		=	
3			x		=	
4			x		=	
5			x		=	
6			x		=	
7			x		=	
8			x		=	
9			x		=	
10			x		=	
11			x		=	
12			x		=	
13			x		=	
14			x		=	
15			x		=	
16			x		=	
17			x		=	
18			x		=	
19			x		=	
20			x		=	

ALCOHOL FUEL OPERATING COSTS

	Per Gallon	Per Year
Labor		
Energy		
Feedstock		
Water		
Enzymes		
Yeast		
Lime		
Acid		
Denaturant		
Interest		
Total Operating Costs		
III. Product Credits		
A. Ethanol 190 Proof (opportunity cost)		
B. DDG-7.2 lbs./gallon		
C. Heat		
D. CO_2		
E. 10% Investment Credit		
F. 10% Energy Credit		
Total		
IV. Analysis		
A. Total Operating Costs		
B. Annual Capital Cost		
Total		
V. Alcohol Fuel Earnings		

DISTILLER'S GRAINS

WHAT IS THE VALUE?

Given: Corn at $2.10 per bushel.
Soybean Oil Meal at $200 per Ton.
Swine Base Mix at $310 per Ton.

Example: 16% Swine Grower Ration

	225	lbs. Soybean Meal
	200	lbs. Base Mix
	1,575	lbs. Corn
112.57	per 2,000 lbs.	

or

$35.20	458	lbs. Distillers grain
	175	lbs. Base Mix
77.37	1,340	lbs. Corn
112.57	per 2,000 lbs.	

$$\frac{\$35.20}{485 \text{ lbs.}} = \$.073/\text{lb.}$$

Example: 14% Swine Grower Ration

	175	lbs. Soybean Meal
	175	lbs. Base Mix
	1,650	lbs. Corn

$106.49 per 2,000 lbs.

or

$24.16

	400	lbs. Distilled Grains
82.30	190	lbs. Base Mix
	1,410	lbs. Corn

$106.49 per 2,000 lbs.

$$\frac{\$24.16}{400 \text{ lbs.}} = \$.06/\text{lb.}$$

Reference: Midland Cooperator, Vol. 48, No. 2, January 28, 1980

ALCOHOL FUEL PLANT FEASIBILITY

Corn Grain Feedstock

Annual Fuel Use	_____	_____	_____	_____
Fuel Storage Available	_____	_____	_____	_____
Column Size	12"	8"	6"	4"
Plant Operation Time	10 hrs. @ 20 gal/hr.	10 hrs. @ 12 gal/hr.	10 hrs. @ 8 gal/hr.	10 hrs. @ 6 gal/hr.
	GALLONS PER YEAR PRODUCED			
90 Days	_____	_____	_____	_____
150 Days	_____	_____	_____	_____
210 Days	_____	_____	_____	_____
250 Days	_____	_____	_____	_____
365 Days	_____	_____	_____	_____
	Gal/Day	Gal/Day	Gal/Day	Gal/Day
Fermentation tank(s) 10% beer	_____	_____	_____	_____
Cook Tank Size at 2 batches/day	_____	_____	_____	_____
Boiler Size	A	B	C	D
H.P.	_____	_____	_____	_____
BTU's/hr.	_____	_____	_____	_____
Bushel corn/day at 1 bu./30 Gal. H_2O.	_____	_____	_____	_____
1 Bushel yields	2.5 Gal.	2.5 Gal.	2.5 Gal.	2.5 Gal.

FEEDING ANALYSIS

Pounds of Mash/Year (7.2 lbs./gal)	_____	_____	_____	_____
Tons of Mash	_____	_____	_____	_____

Cattle Feed 5 lb/head/day dry-10 lb/head/ day wet	Number of Head	Number of Head	Number of Head	Number of Head
105 Days	_____	_____	_____	_____
210 Days	_____	_____	_____	_____
270 Days	_____	_____	_____	_____
365 Days	_____	_____	_____	_____

A farmer can determine his earnings from an acre of corn by comparing market options:

Market Option (sell at elevator)		Market Option (process into fuel)
Income from Sale of Grain		Income from Sale of Ethanol at 2.5 Gallons Per Bushel.
Cost of Production	Less	Cost of Production
- - -	Less	Cost of Processing
- - -	Plus	Value of Distilled Grains
Return over Costs	Equals	Return over Costs

YIELD	PRICE	GROSS	FERT	CORN CHEM	SEED AND OTHER	SPEC. LABOR	CUSTOM WORK	POWER AND MACH.	LAND COST	INT-MACH.	COST/ UN PROD.	TOTAL COST	BREAK EVEN YIELD	RETURN OVER COSTS
122.0	2.00	244.00	60.00	6.00	9.00	10.00	.00	49.00	70.00	6.00	2.00	227.00	113.00	18.00
118.0	2.00	237.00	65.00	17.00	12.00	.00	.00	48.00	50.00	9.00	2.00	226.00	113.00	12.00
107.0	2.00	214.00	34.00	17.00	13.00	.00	2.00	63.00	60.00	5.00	2.00	216.00	108.00	-1.13
107.0	2.00	215.00	59.00	17.00	17.00	1.00	.00	30.00	70.00	5.00	2.00	212.00	106.00	4.00
140.0	2.00	280.00	39.00	12.00	12.00	.00	3.00	65.00	55.00	7.00	2.00	209.00	104.00	71.00
98.0	2.00	197.00	40.00	11.00	15.00	.00	28.00	42.00	60.00	2.00	2.00	206.00	103.00	-9.22
109.0	2.00	218.00	46.00	12.00	14.00	3.00	.00	54.00	50.00	10.00	2.00	203.00	104.00	16.00
100.0	2.00	200.00	37.00	9.00	9.00	.00	2.00	65.00	50.00	6.00	2.00	196.00	98.00	5.00
109.0	2.00	217.00	50.00	17.00	14.00	.00	.00	46.00	50.00	5.00	2.00	195.00	98.00	22.00
115.0	2.00	240.00	38.00	13.00	12.00	.00	2.00	51.00	50.00	8.00	2.00	190.00	95.00	50.00
125.0	2.00	250.00	34.00	10.00	10.00	.00	5.00	53.00	50.00	9.00	2.00	190.00	95.00	60.00
96.0	2.00	191.00	25.00	7.00	15.00	1.00	.00	36.00	70.00	2.00	2.00	174.00	87.00	17.00
94.0	2.00	188.00	25.00	9.00	13.00	.00	1.00	57.00	50.00	6.00	2.00	130.00	89.00	10.00
50.0	2.00	100.00	24.00	11.00	12.00	.00	3.00	18.00	50.00	.40	3.00	127.00	63.00	-27.00

-89-

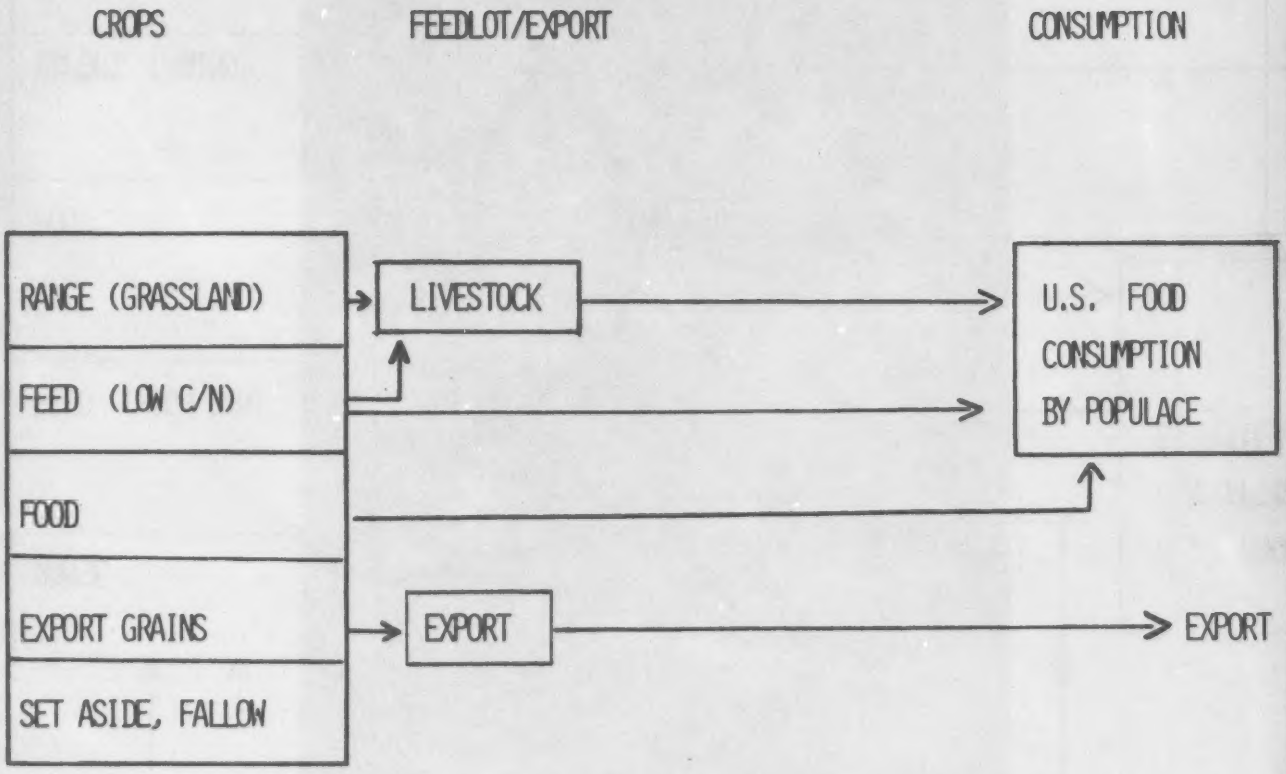
YIELD	PRICE	GROSS	FERT	CORN CHEM	SEED AND OTHER	SPEC. LABOR	CUSTOM WORK	POWER AND MACH.	LAND COST	INT-MACH.	COST/ UN PROD.	TOTAL COST	BREAK EVEN YIELD	RETURN OVER COSTS
140.0	2.00	280.00	39.00	12.00	12.00	.00	3.00	65.00	55.00	7.00	2.00	209.00	104.00	71.00
125.0	2.00	250.00	34.00	10.00	10.00	.00	5.00	53.00	50.00	9.00	2.00	190.00	95.00	60.00
115.0	2.00	240.00	38.00	13.00	12.00	.00	2.00	51.00	50.00	8.00	2.00	190.00	95.00	50.00
109.0	2.00	217.00	50.00	17.00	14.00	.00	.00	46.00	50.00	5.00	2.00	195.00	98.00	22.00
122.0	2.00	244.00	60.00	6.00	9.00	10.00	.00	49.00	70.00	6.00	2.00	227.00	113.00	18.00
96.0	2.00	191.00	25.00	7.00	15.00	1.00	.00	36.00	70.00	2.00	2.00	174.00	87.00	17.00
109.0	2.00	218.00	46.00	12.00	14.00	3.00	.00	54.00	50.00	10.00	2.00	203.00	104.00	16.00
118.0	2.00	237.00	65.00	17.00	12.00	.00	.00	48.00	50.00	9.00	2.00	226.00	113.00	12.00
94.0	2.00	188.00	25.00	9.00	13.00	.00	1.00	57.00	50.00	6.00	2.00	130.00	89.00	10.00
100.0	2.00	200.00	37.00	9.00	9.00	.00	2.00	65.00	50.00	6.00	2.00	196.00	98.00	5.00
107.0	2.00	215.00	59.00	17.00	17.00	1.00	.00	30.00	70.00	5.00	2.00	212.00	106.00	4.00
107.0	2.00	214.00	34.00	17.00	13.00	.00	2.00	63.00	60.00	5.00	2.00	216.00	108.00	-1.13
98.0	2.00	197.00	40.00	11.00	15.00	.00	28.00	42.00	60.00	2.00	2.00	206.00	103.00	-9.22
50.0	2.00	100.00	24.00	11.00	12.00	.00	3.00	18.00	50.00	.40	3.00	127.00	63.00	-27.00

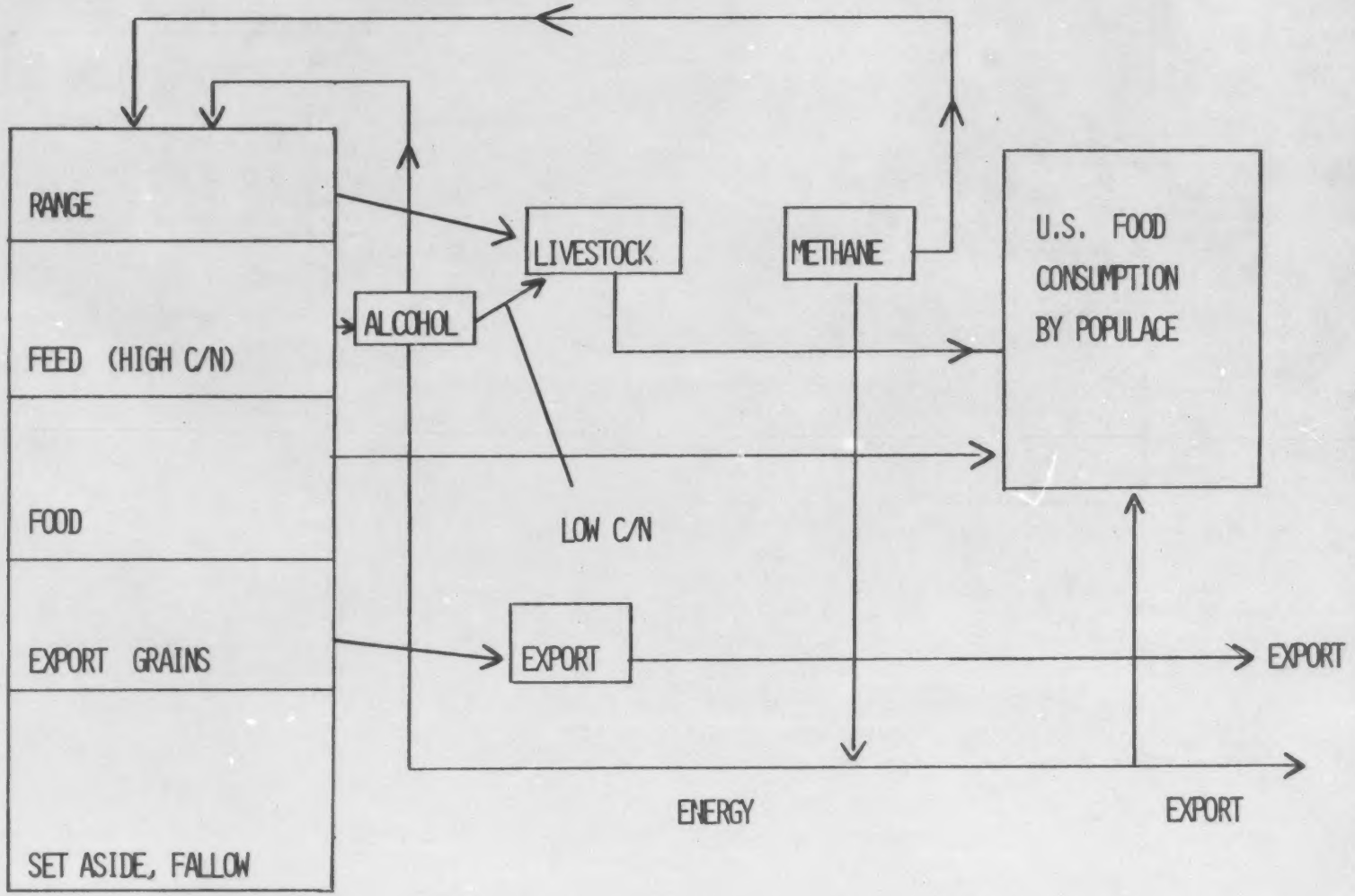
"Summary from 1979 Farm Management Analysis"

FEEDSTOCK FINANCIAL ANALYSIS

Feedstock or Crop	Production Cost Per Acre	Bushels Yield Per Acre	Gallons Ethanol Per Acre	Ethanol Value Per Gallon	Return per Acre	Earnings

POSSIBLE CROP PRODUCTION SCENARIO





PRESENTED BY: JACK HERSHEY OF COLBY, KANSAS WORKSHOP

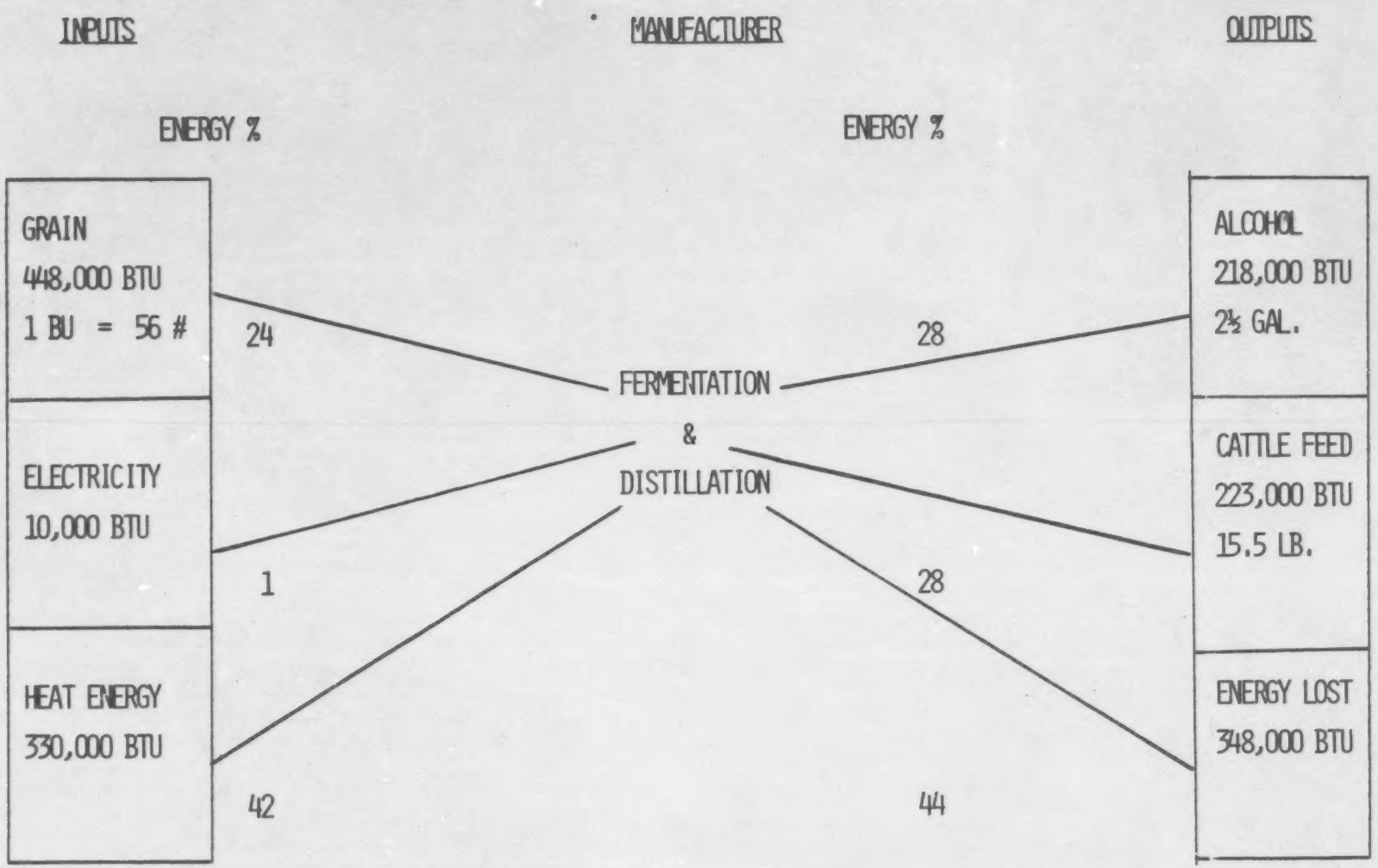


FIG. 1 - ENERGY AND MATERIALS BALANCE FOR ETHANOL MANUFACTURE (SOURCE, C.L. CRAY JR., MID-WEST SOLVENTS)

By-Product Uses

Objectives:

1. To describe uses for carbon dioxide, distilled grains, and spent water.
2. To compare feed value of distilled grains to other feeds.
3. To balance a livestock ration using distilled grains as a protein suppliment.

Class Activities:

1. Test protein in feedstock and compare with protein in distilled mash.
2. Balance a ration using computer program to substitute distilled proteins for commercial proteins.

References:

1. Small-Scale Fuel Alcohol Production, Chapter VI.
2. Makin' It On the Farm, by Micki Nellis, Chapter V, P: 35.

Feeding Distilled Grains

A. Feed Analysis Table

1. How to compare different feedstocks.
2. Ingredient substitution factors.

B. High By-Pass Protein Sources

1. Definition.
2. Relative value of different sources.
3. Substitution samples.

C. Basic Ration Formulation

1. Using various feedstocks.
2. Considering nutrient composition.
3. Balancing the ration.

D. Examples of Rations

1. Dairy
2. Beef
3. Swine
4. Poultry
5. Other Livestock

E. Practicum In Ration Formulation

Relative Value of Various High By-Pass
Protein Sources

Protein Source	Percent Protein	Relative Protein Efficiency
Soybean Meal	45	100
Brewers Dried Grains	28	190
Distillers Dried Grains with Solubles	28	173
Alfalfa Dehy.	17	190
Meat Meal	50	185

Substitution Samples for a Ton of
Soybean Meal - (High By-Pass Protein)

Protein Source	Amount of Protein (Lbs.)	Corn (Lbs.)	Urea (Lbs.)
Soybean Meal	2,000		
Brewers Dried Grains	1,619	229	152
Distillers Dried Grains	1,853	12	135
Distillers Dried Grains with Solubles.	2,346	0	87
Alfalfa Dehy.	2,788	0	152
Meat Meal	780	1,073	147

1,400 lbs. cow - Dairy Budget 60 lbs. of 3.5% milk/day

Feeding Program: 20 lbs. of legume - grass hay
40 lbs. of corn silage
17 lbs. of grain mixture

16% Grain Mixture:

Ingredient	Cost/Cwt.	Pounds	Cost of Ration
Shelled corn	4.46	1,214	54.14
Brewers Dried Grain (26% of ration)	6.00	520	31.20
44% Protein Supplement	12.00	231	27.72
Mono Phosphorus	16.00	9	1.62
Trace Mineral Salt	3.00	20	0.60
Vitamen Premix	19.00	5	0.95
Total		1,999 lbs.	$116.23

4.42 lbs. of BDG/Hd/day
12.58 lbs. of other ingredients
17.00 lbs. of Grain mix/Hd/day

	Per Year	
	43 Cow Herd	Per Animal
4.42 lbs. of BDG x 365 days/year	69,371.90 lbs. (34.68 tons)	1,613.30 lbs.
Bushels of corn to provide the BDG	3,854	89.6
Alcohol Produced (2.5 gal/bu) (gallons)	9,635	224

Yearling Steer - Beef Budget - High Grain Ration -

Performance:	Head	Cwt. Gain
Purchase Weight, lbs.	600	
Selling Weight, lbs.	1,100	
Total gain, lbs.	500	
Average daily gain, lbs.	2.40	
Days on feed	208	

Feed Requirements and costs:

Corn. . . 66.67 Bu. at $2.35	156.67	31.32
Hay . . . 33 ton at $45	15.00	3.00
Prot. Suppl. 200 lbs. at 9.00	18.00	3.60
Mineral . 33 lbs. at 5.00	1.67	.33
Total feed cost	191.33	38.27

Protein Supplement (in lbs.)

Per Ton	Ingredient	Above ration
666	Linseed Oil Meal	69
666	Brewers Dried Grains (32% of Supplement)	66
268	Cane Molasses	26
214	Urea	21
134	Bone Meal	13
36	Iodized Salt	3
8	Trace Minerals	.8
8	Vit. A & D Supplement	.8
2,000		200

3.66 Bu. of corn used to produce the 66 lbs. of BDG and 9.15 gallons of alcohol.

Swine Budget

Performance:	Head	Cwt. Gain
Weight Sold	220 lbs.	
Weight Purchased	40 lbs.	
Days on Feed	112	
Average Daily Gain	1.60 lbs.	
Pounds of feed/lb. of gain	3.67	

Feed Requirements/Head and Costs:		
Corn. . . 9.75 Bu. at 2.60	25.34	14.08
Protein Suppl. 117 lbs. @ $14	16.36	9.09
Total Feed Cost	41.70	23.17

35% Protein Supplement (in lbs.)

Per Ton	Ingredient	Above ration
260	Wheat Middlings	14
600	Brewers Dried Grains (30% of Supplement)	34
200	Tankage	11
150	Fish Meal	8
700	Soybean Meal	40
40	Salt	2
40	Steamed Bone Meal	2
10	Antibiotic Supplement	6
2,000		117

2 bushels of corn was used to produce the BDG and 5 gallons of alcohol was produced.

III YIELD STATISTICS

FEED STOCK	ALCOHOL YIELD	PROTEIN MEAL	PROTEIN CONTENT (% of Dry Weight)
CORN	2.73 gal/bu (190 proof) 2.55 gal/bu (200 proof)	18 lb./bu.	29-30%
WHEAT	2.6 gal/bu (average)	20.7 lb./bu	36%
GRAIN SORGHUM	2.6 gal/bu	16.8 lb./bu	29-30%
STARCH GRAINS	2.5 gal/bu	17.5 lb./bu	27.5%
POTATOES (75% Moisture)	1.4 gal/cwt	14.8 lb./cwt	10%
SUGAR BEETS	20.3 gal/ton	264 lb./ton	20%
MOLASSES (50% Sugar)	68 gal/ton	---	---

Feedstuff	% Protein	% Fat	% Fiber	% Ca.	Total % Phos.	% Ash	% Dry Matter	True Metabolizable Energy Cal/lb.
Brewers Dried Grains	27	7.0	12.0	.25	.6	4.0	93	1,400
Distillers Dried Grains with Solubles (corn)	27	8.0	8.5	.25	.9	4.6	91	1,335
Corn	8.5	3.8	2.5	.01	.25	1.5	86	1,610
Corn & Cob Meal	7.5	3.0	8.2	.04	.20	1.5	86	---
Oats	11.5	4.0	12.0	.08	.33	3.5	89	1,470
Soybean Meal	44	.5	6.5	.25	.60	6.0	90	1,205
Values of wet Distillers Grains from Reese Bros. still.	29.4		9.78	.37	1.02		35	

Note: High value in phosphorus

Table VI - 8. Animal Consumption of Distillers By-Products.

Feed	Production Rate	Kg Feed/day	Lb Feed/day	DDGS Lb/day	Stillage, gal/day 10% solids	Stillage, gal/day 20% solids
Type of Animal						
550 lb. calf (Hay ration)	2 lb/day, gain	6.2	13.7	5.8	6.3	3.1
770 lb. steer	2.8 lb/day, gain	8.8	19.4	8.5	9.2	4.6
1,330 lb. cow	50 lb/day, 3.5% milk	16.8	37.0	6.6	7.2	3.6
60 lb. pig	1.3 lb/day, gain	1.5	3.3	1.1	1.2	.6
Pullet, age 3.7 weeks		.057	.13	.13	NA	NA
Pullet, age 7.5 weeks		.1	.22	.22	NA	NA

NA = Not applicable

U.S.D.A. Small-Scale Fuel Alcohol Production

Lessons 8 and 9

See: Utilization of Alcohol Fuel In Spark and Diesel Engines
by Don Berndt and Ron Stengel
(Separate Publication)

Government Permits and Regulations

Objectives:

1. To discuss Federal Laws and Regulations that apply to alcohol fuel plants.
2. To discuss State Laws and Regulations that apply to alcohol fuel plants.
3. To discuss local regulations and permits required for alcohol fuel plants.
4. To identify tax credits that apply to an alcohol fuel plant.

Class Activities:

1. Invite regional ATF person to discuss regulations and bring current ATF applications.
2. Complete a sample form required for an alcohol fuels permit.

Alcohol Fuel Regulatory Agencies

Federal Office for Midwest Region:

Regional Regulatory Administrator
Bureau of Alcohol, Tobacco and Firearms
230 S. Dearborn Street
15th Floor
Chicago, IL 60604

Includes Staff of:

Illinois, Iowa, Kansas,Minnesota, Missouri,
Nebraska, North Dakota, South Dakota,
Wisconsin.

This office will answer questions and provide application forms necessary for an alcohol fuels permit;

Boyd W. Dick - ATF Supervisor Midwest Region
Room 650, Federal Building & U.S. Courthouse
North Robert Street
St. Paul, MN 55101

Phone: 612-725-7496

State Offices:

Local Offices:

County -

INFORMATION CONCERNING STATE OF MINNESOTA REQUIREMENTS PERTAINING TO GASOHOL

All persons producing ethyl alcohol must obtain a Permit to Possess Ethyl Alcohol (same as Tax Free Users) from the Liquor Control Commission, 2nd Floor Hanover Building, 480 Cedar St., St. Paul, MN 55101, 296-6159 (cost -- $5.00).

Also all persons producing alcohol, either commercially or just for their own use (i.e. Experimental DSP) must be licensed as a distributor of Motor Fuels. This license costs $5.00 per year (year runs July 1 - June 30). All alcohol used as a motor fuel is subject to Motor Fuels Tax at the time it is used as a motor fuel. It is taxed even if it is used in farm vehicles. However, tax paid on alcohol used as a fuel in farm vehicles may be refunded if licensee can prove that it was used as a fuel in farm vehicles. There is no refund allowed on alcohol used as a fuel in cars, furnaces, etc. Tax is paid monthly on a form which must be submitted along with the tax payment by the 23rd of the following month. The licensee then may submit another form to the Revenue Department Refund Division to get a refund of tax for the alcohol used in farm vehicles.

License applications and tax return forms may be obtained from the Minnesota Department of Revenue, Petroleum & Motor Fuels Tax Division, 1276 University Avenue, St. Paul, MN 55104.

This information per Ron Daughty of the Motor Fuels Tax Division 12/17/79.

DEPARTMENT OF THE TREASURY – BUREAU OF ALCOHOL, TOBACCO AND FIREARMS

APPLICATION AND PERMIT FOR ALCOHOL FUEL PRODUCER UNDER 26 U.S.C. 5181

INSTRUCTION SHEET FOR ATF FORM 5110.74

PLEASE READ CAREFULLY. AN INCOMPLETE OR INCORRECT APPLICATION WILL DELAY YOUR ALCOHOL FUEL PRODUCER'S PERMIT.

1. PURPOSE. The application is completed by a person (applicant) who would like to establish a plant to produce, process, and store, and use or distribute distilled spirits to be used exclusively for fuel use under 26 U.S.C. 5181. Distilled spirits means only ethanol or ethyl alcohol. The production of methanol does not require a permit from the Bureau of Alcohol, Tobacco and Firearms. The production of distilled spirits from petroleum, natural gas, or coal is not allowed by the Alcohol Fuel Producers Permit.

2. GENERAL PREPARATION. Prepare this form and any attachments in duplicate. Use separate sheets of approximately the same size as this form when necessary or as required. Identify these separate sheets with your name, and attach to form.

3. WHERE TO FILE. Submit application to the appropriate regional regulatory administrator. (A listing of their offices and the areas they are responsible for is on the reverse.)

4. TYPE OF APPLICATION. (See item 1. of application). The type of permit you need, small, medium, or large, depends on how many proof gallons of distilled spirits you intend to produce and receive by transfers from other plants during one calendar year. The number of proof gallons may be calculated by taking the proof of the spirits multiplied by the wine gallons (your standard American gallon) and dividing by 100. For example:

   50 gallons of 190° proof spirits =
   190 x 50 ÷ 100 = 95 proof gallons.

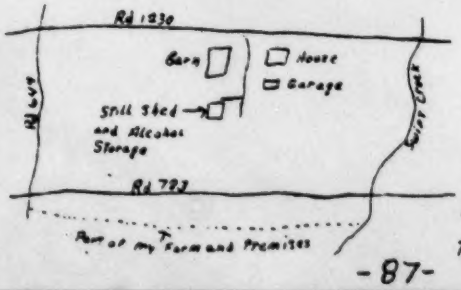
   After determining the quantity of spirits to be produced and received by transfers from other plants, check applicable box in item 1.

5. AMENDED PERMIT. Item 2. is only completed when changing or amending an existing permit.

6. INFORMATION ABOUT APPLICANT CURRENTLY ON FILE WITH REGIONAL REGULATORY ADMINISTRATOR NEED NOT BE RESUBMITTED. State in item requesting such information the type and the number of the license or permit for which the information was filed.

7. CAPACITY OF STILLS. Item 9.d. asks for the capacity of your still(s) in proof gallons. The capacity should be given as the greatest number of proof gallons of spirits that could be distilled in a 24 hour period. Capacity of column still may be shown by giving the diameter of the base and the number of plates or packing material. The capacity of a pot or kettle still may be shown by giving the volumetric (wine gallon) capacity of the pot or kettle.

8. SAMPLE DIAGRAM OF PREMISES. Item 12. requires a diagram of your plant premises. It can be drawn by hand and does not have to the drawn to scale. Below is a sample of such a diagram.



My farm is 1,200 acres, 1,000 acres are bounded by Rd. 649, 1230, 783 and Swift Creek. 200 acres are just the other side of Rd 783.

105

9. ITEM 15—SIGNATURE OF/FOR APPLICANT. (a) Individual owners sign for themselves; (b) partnerships have all partners sign, or have one partner who has attached an authorization to act on behalf of all the partners (unless this authorization is provided by State law); (c) corporations have an officer, director, or other person who is specifically authorized by the corporate documents sign; (d) any other person who signs on behalf of the applicant must submit ATF F 1534 (5000.8), Power of Attorney or other evidence of their authority.

10. ADDITIONAL INSTRUCTIONS FOR APPLICANT OF SMALL ALCOHOL FUEL PLANT. Complete all items on the application form. Be sure that you sign and date the form in items 15. and 16. NO ADDITIONAL INFORMATION IS REQUIRED.

11. APPLICANT FOR PERMIT OF MEDIUM AND LARGE ALCOHOL FUEL PLANT. Complete all items on the form. Supply in duplicate the additional information and forms as stated below.
    a. The following information is requested for an individual proprietor, each partner, or each director of a corporation or similar entity and each officer of the corporation or similar entity who will have responsibilities and connection with the operations covered by the permit. In addition applicants for large plants shall show the same information for each interested person who is an individual as listed in the statement of interest in the organizational documents required by 27 CFR 19.941.
       (1) full name including middle name;
       (2) title in connection with applicants' business;
       (3) social security number;
       (4) date of birth;
       (5) place of birth; and
       (6) address of residence.
    b. A statement as to whether the applicant or any person required to be listed by the instructions above has been previously convicted of any violation of Federal or State law (other than minor traffic violations).
    c. A statement of the maximum quantity of distilled spirits to be produced and received from other plants during a calendar year.
    d. A Distilled Spirits Bond, ATF F 5110.56, as required by 27 CFR 19.956.
    e. Any other information required by the regional regulatory administrator after examination of this application.

SPECIAL INSTRUCTIONS FOR ALL APPLICANTS

12. OPERATIONS BEFORE ISSUANCE OF PERMIT. Unless otherwise specifically authorized by law or regulations, an applicant for an Alcohol Fuel Producer Permit may not engage in operations until the permit has been issued by the regional regulatory administrator.

13. STATE AND LOCAL LAWS. This permit does not allow you to operate in violation of State or local laws. Applicants should check with appropriate State and local authorities before engaging in alcohol fuel plant operations.

14. ATF FORMS AND REGULATIONS FOR ALCOHOL FUEL PLANTS. ATF forms and publications including regulations for alcohol fuel producers may be ordered from the ATF Distribution Center, 3800 S. Four Mile Run Drive, Arlington, VA 22206.

FOR QUESTIONS CONCERNING YOUR APPLICATION CONTACT YOUR REGIONAL REGULATORY ADMINISTRATOR AT THE ADDRESS SHOWN BELOW.

IF APPLICANT'S BUSINESS IS TO BE CONDUCTED IN:	CALL OR WRITE: REGIONAL REGULATORY ADMINISTRATOR ATTN.: CHIEF, TECHNICAL SERVICES BUREAU OF ALCOHOL, TOBACCO & FIREARMS
Connecticut, Maine, Massachusetts New Hampshire, New York, Rhode Island, Vermont, Virgin Islands, Puerto Rico	6 World Trade Center, 6th Floor New York, New York 10048 PHONE: NY ONLY 800-442-8275 ALL OTHER 800-223-2162
Delaware, District of Columbia, Maryland, New Jersey, Pennsylvania, Virginia	2 Penn Center Plaza Philadelphia, Pennsylvania 19102 PHONE: PA ONLY 800-462-0434 ALL OTHER 800-523-0677
Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, Tennessee	P.O. Box 2994 Atlanta, Georgia 30370 PHONE: GA ONLY 800-282-8878 ALL OTHER 800-241-3701
Indiana, Kentucky, Michigan, Ohio, West Virginia	550 Main Street Cincinnati, Ohio 45202 PHONE: OH ONLY 800-582-1880 ALL OTHER 800-543-1932
Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Wisconsin	230 S. Dearborn Street Chicago, Illinois 60604 PHONE: IL ONLY 800-572-3178 ALL OTHER 800-621-3211
Arkansas, Colorado, Louisiana, New Mexico, Oklahoma, Texas, Wyoming	Main Tower 1200 Main Street Dallas, Texas 75202 PHONE: TX ONLY 800-442-7251 ALL OTHER 800-527-9380
Alaska, Arizona, California, Hawaii, Idaho, Montana, Nevada, Oregon, Utah, Washington, Guam	525 Market Street San Francisco, California 94105 PHONE: CA ONLY 800-792-9811 ALL OTHER 800-227-3072

PRIVACY ACT INFORMATION

The following information is provided pursuant to Section 3 of the Privacy Act of 1974 (5 U.S.C. 552(a)(e)(3)):

1. AUTHORITY. Solicitation of this information is made pursuant to 26 U.S.C. 5181. Disclosure of this information by the applicant is mandatory if the applicant wishes to obtain an Alcohol Fuel Producers Permit.

2. PURPOSE. To determine the eligibility of the applicant to engage in permit operations, to determine location and extent of the permises, and to determine whether the operations will be in conformity with law and regulations.

3. ROUTINE USES. The information will be used by ATF to make determinations set forth in paragraph 2. In addition, the information may be disclosed to other Federal, State, foreign and local law enforcement and regulatory agency personnel to verify information on the application where such disclosure is not prohibited by law. The information may further be disclosed to the Justice Department if it appears that the furnishing of false information may constitute a violation of Federal law. Finally, the information may be disclosed to members of the public in order to verify the information on the application where such disclosure is not prohibited by law.

4. EFFECTS OF NOT SUPPLYING REQUESTED INFORMATION. Failure to supply complete information will delay processing and may result in a denial of the application.

The following information is provided pursuant to Section 7(b) of the Privacy Act of 1974:

Disclosure of the individual's social security number is voluntary. Pursuant to the statutes above, ATF is authorized to solicit this information. The number may be used to verify the individual's identity.

DEPARTMENT OF THE TREASURY
BUREAU OF ALCOHOL, TOBACCO AND FIREARMS

APPLICATION AND PERMIT FOR ALCOHOL FUEL PRODUCER

(Prepare in Duplicate. See Instructions)

ATF USE ONLY

DATE RECEIVED	DATE RETURNED AFTER CORRECTIONS
PERMIT NUMBER	EFFECTIVE DATE

1. ORIGINAL APPLICATION *(Check applicable box)*

- ☐ SMALL – 10,000 Proof Gallons or less*
- ☐ MEDIUM – More than 10,000 Proof Gallons but not more than 500,000*
- ☐ LARGE – More than 500,000 Proof Gallons*

*Proof Gallons to be produced and received during one calender year *(See Instruction 4.)*

2. AMENDED PERMIT *(Check applicable box(es))*

(Change In)

- ☐ LEVEL OF OPERATIONS
- ☐ OFFICERS OF CORPORATION *(Medium and Large Plants Only)*
- ☐ CONTROL OF CORPORATION *(Medium and Large Plants Only)*

(Change In)

- ☐ NAME OF PROPRIETOR
- ☐ LOCATION OF PLANT
- ☐ OTHER *(Explain)*

PERMIT NO
AFP–

3. NAME OF OWNER *(If partnership, include name of each partner)*

4. DAYTIME TELEPHONE NUMBER *(Include Area Code)*

5. LOCATION *(If no street address show rural route)*

6. MAILING ADDRESS *(If different from plant location) (RFD or Street No., City, State, ZIP Code)*

7. PREMISES FOR ALCOHOL FUEL PLANT ARE *(Check applicable box)*

- ☐ OWNED BY THE APPLICANT *(Skip Item 8.)*
- ☐ NOT OWNED BY THE APPLICANT *(Complete Item 8.)*

8. OFFICERS OF THE BUREAU OF ALCOHOL TOBACCO AND FIREARMS ARE GRANTED ACCESS TO THE PREMISES DESCRIBED BY THIS APPLICATION FOR A ALCOHOL FUEL PRODUCERS PERMIT.

NAME OF PROPERTY OWNER

SIGNATURE OF/FOR PROPERTY OWNER | DATE

9. STILLS FOR FUEL PRODUCTION ON THE PLANT PREMISES

STILL MANUFACTURER *(If owner is the manufacturer, write "Owner")* (a)	SERIAL NUMBER OF STILL (b)	KIND OF STILL *(State whether Kettle, Pot, Charge Chamber, Continuous Still, or Other (Specify))* (c)	CAPACITY *(Proof Gallons) (See Instruction 7.)* (d)

10. BASIC MATERIALS *(Other than yeasts or enzymes)* **TO BE USED IN PRODUCTION OF SPIRITS** *(Check applicable box(es))*

- ☐ GRAIN *(Corn, Wheat, Sorghum, Barley, etc.)* AND OTHER STARCH PRODUCTS *(Potatoes, Sweet Potatoes, etc.)*
- ☐ SUGAR BASED CROPS *(Cane Sugar, Sugar Beets, Molasses, Sweet Sorghum, Beet Fodder, etc.)* AND PRODUCTS
- ☐ FRUITS OR FRUIT PRODUCTS *(Grapes, Peaches, Apples, etc.)*
- ☐ FORAGE CROPS *(Alfalfa, Sudan Grass, Forage Sorghum, etc.)*
- ☐ CROP RESIDUE *(Garbage or other refuse)*
- ☐ OTHER *(Specify)* _____

11. DESCRIBE SECURITY MEASURES *(Such as use of locks, fences, building alarms, etc.)* **TO PROTECT PREMISES, CONTAINERS, STILL(S) AND BUILDINGS WHERE SPIRITS ARE STORED**

107

89

ATF F 5110.74 (6-80)

12. DIAGRAM OF PLANT PREMISES *(In the space provided or by attached map or diagram, show the area to be included for the alcohol fuel plant. Identify roads, streams, lakes, railroads, buildings, and other structures or topographical features on the diagram. Show location(s) where alcohol fuel plant operations will occur. The diagram should be in sufficient detail to locate your operations and premises.) (See directions for sample diagram.)*

13. I WILL COMPLY WITH THE CLEAN WATER ACT *(33 U.S.C. 1341(a)). (Will not discharge into navigable waters of the U.S.)*

☐ YES ☐ NO

14. IF THIS APPLICATION IS APPROVED AND THE PERMIT IS ISSUED, I CONSENT TO THE DISCLOSURE OF THE NAME AND ADDRESS SHOWN ON THE APPLICATION IN AN ATF PUBLICATION, "ALCOHOL FUEL PRODUCERS", WHICH MAY BE DISTRIBUTED ON REQUEST TO THE GENERAL PUBLIC *(including media, business, civic, government agencies, and others)*. UNDER 26 U.S.C. 6103 YOU HAVE A LEGAL RIGHT NOT TO GIVE THIS RELEASE.

☐ YES ☐ NO *(A no response will have no effect on the consideration given this application)*

APPLICANTS FOR MEDIUM AND LARGE ALCOHOL FUEL PLANTS MUST ATTACH THE ADDITIONAL INFORMATION REQUIRED IN INSTRUCTIONS

Under the penalties of perjury, I declare that I have examined this application, including the documents submitted in support thereof or incorporated therein by reference, and, to the best of my knowledge and belief, it is true, correct, and complete.

15. SIGNATURE OF/FOR APPLICANT	16. TITLE *(Owner, Partner, Corporate Officer)*

STOP
MAKE NO FURTHER ENTRIES ON THIS FORM

ALCOHOL FUEL PRODUCERS PERMIT
UNDER 26 U.S.C. 5181

1. EFFECTIVE DATE

2. PERMIT NUMBER

AFP –

Pursuant to the above application and subject to applicable law and regulations and to the conditions set forth below you are hereby authorized and permitted at the premises described in your application to produce, process and store, and use or distribute distilled spirits (Not including distilled spirits produced from petroleum, natural gas or coal) exclusively for fuel use. The quantity to be produced and received from other plants during the calendar year is limited to the quantity stated in this application.

This permit is continuing, and will remain in force until suspended, revoked, voluntarily surrendered, or automatically terminated. This permit does not allow you to operate in violation of State or local laws.

THIS PERMIT IS NOT TRANSFERABLE. In the event of any lease, sale, or other transfer of the operations authorized, or of any other change in the ownership or control of such operations, this permit shall automatically terminate. (See 27 CFR 19.145 AND 19.949)

3. SIGNATURE OF REGIONAL REGULATORY ADMINISTRATOR, BUREAU OF ALCOHOL, TOBACCO AND FIREARMS

CONDITIONS

1. That the permittee in good faith complies with the provisions of Chapter 51 of Title 26 of the United States Code and regulations issued thereunder.

2. That the permittee has made no false statement as to any material fact in his application for this permit.

3. That the permittee discloses all the material information required by law and regulation.

4. That the permittee shall not violate or conspire to violate any law of the United States relating to intoxicating liquor and shall not be convicted of any offense under the United States Code punishable as a felony or of any conspiracy to commit such an offense.

5. That all persons employed by the permittee in good faith observe and conform to all of the terms and conditions of this permit.

6. That the permittee engages in the operations authorized by this permit within a 2 year period.

7. This permit is conditioned on compliance by you with the Clean Water Act (33 U.S.C. 1341(a)).

FEDERAL ENERGY CREDITS

Federal Income Tax Laws indentify two types of energy credits. The first is a Business Energy Investment Credit. The second credit available to taxpayers is a Residential Energy Credit and applies to Non-Business property. The following outline provides details on Business Energy Investment Credit. To qualify for the credit an item must be used for business purposes, and must reduce conventional energy needs.

Business Energy Investment Credit

I. 20 percent total credit

   A. 10 percent Investment Credit
   B. 10 percent Energy Credit

II. Item must have a life of 3 years of more to qualify.

III. Types of Property that qualify -

   A. Solar collector - includes heat storage system.
   B. Wind generator
   C. Alcohol Fuels facilities.

IV. Solar and Wind credits are refunded.

Acknowledgements

This curriculum was written and prepared through the efforts of the following people:

Don Berndt
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Ron Stengel
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Diesel Mechanics

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Canby AVTI
Adult Education Coordinator

Neale Deters
Granite Falls AVTI
Farm Management Instructor

Richard Jepson
Granite Falls AVTI
Farmer

Jim Boerboom
Granite Falls AVTI
Alcohol Fuels Coordinator

Marlyn Wacholz
Granite Falls AVTI
Adult Education Coordinator

Bibliography

General:

United States Department of Agriculture, Small-Scale Fuel Alcohol Production, Washington, DC 20250 ($)

U. S. Department of Energy, Fuel From Farms - A Guide to Small Scale Ethanol Production, P.O. Box 62, Oakridge, Tennessee 37830 (No charge)

National Alcohol Fuels Producers Association, Lincoln, NE, A Learning Guide for Alcohol Fuel Production, 1979; 600 p. Available from NAFPA, 2444 B. Street, Lincoln, NE 68502, $75 with membership.

Crombie, L., Making Alcohol Fuel - Recipe and Procedure, 1979, 40 p., available from Rutan Publishing, P.O. Box 3585, Minneapolis, MN 55403. ($8.00)

Gibat and Gibat, The Lore of Still Building, 1978, 128 p. Available from Micro Tech Laboratories, Inc. R.R. 2, Box 19, Logan, IA 51546. ($4.00)

Department of Energy, "Report of the Alcohol Fuels Policy Review," Report No. DOE/PE-0012, June 1979, 119 p. Available from Superintendent of Documents, Stock No. 061-000-00313-4, Washington, DC.

Ethel Alcohol Handbook, Ind. Chem. Div., Njenjay Chemical Company, Div. of Humble Oil, 60 W. 49th Str., New York, NY 10020.

Nellis, Micki, Makin' It On the Farm, Published by American Agriculture News, P.O. Box 100, Iredell, TX 76649. ($2.95)

Lyons, Dr. T.P., The Theory and Practice of Fermentation in the Production of Alcohol, Biocon (U.S.) Inc., 261 Midland Avenue, Lexington, KY 40507. Phone 606-254-0517.

Magazines:

Bio Times, The International Biomass Institute, 1522 K. Street NW, Suite 500, Washington, DC 20005. ($10 including membership (monthly))

Farm Show Magazine, 8500 - 210 Street, Lakeville, MN 55044. ($9/year)

Gasohol U.S.A., National Gasohol Commission, Box 9547, Kansas City, MO 64133. $12/year (monthly).

Mother Earth News, Mother Earth News, Box 70 Hendersonville, NC 28739, $15/year (bi Monthly).

Farm Energy, 200 West Towers, 1200 - 35th Street, West Des Moines, IA 50265. $25/year (monthly).

Personal References:

Lincoln B. Justice
National Alcohol Fuel Producers Association
2444 B. Street
Lincoln, Nebraska 68502
Phone: 402-477-3101

Glenn D. Kiecker, Secretary
The Minnesota Gasohol Commission
Box 86A, Highways 212 & 71
Olivia, MN 56277
Phone: 348-7897

ATF Supervision - Midwest Region
Boyd W. Dick
Room 650, Federal Building & U.S. Courthouse
North Robert Street
St. Paul, MN 55101
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CONTROLS & GUAGES

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1801 67th Avenue North
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Honeywell Controls
7400 Metro Blvd.
Minneapolis, MN 55430

Simone Engineering
6870-S Shingle Creek Parkway
Minneapolis, MN 55430

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VACUUM PUMPS

Nash Vacuum Pumps
Nash Engineering Company
4820 W. 77 Street
Minneapolis, MN 55430

Modern Equipment Co.
3718 Cedar Avenue
Minneapolis, MN 55430 721-1634

COLUMN PACKING

Maurice A. Knight Co.
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Bell & Gossett
Bernard J. Mulcahy Co., Inc.
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Aurora Pumps
Goetsch, W.E.
5250 W. 74th Street
Minneapolis, MN 55420 831-4340

Marshall Bond
5001 W. 78th Street
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Micro-Pump
Micropump Corporation
1035 Shary Court
Concord, CA 94518 415-687-0101

PFC Equipment
7409 Jolly Lane
Minneapolis, MN
425-7890

Tuthill Pump Co.
12500 South Pulaski Rd.
Chicago, IL 60658
312-389-2500

Midland Warehouse
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Hypro Pumps
Hypro Division
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